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Evaluation of Conservation Management Practices for Northern Bobwhites and Shrub-Scrub Songbirds

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EVALUATION OF CONSERVATION MANAGEMENT PRACTICES FOR NORTHERN BOBWHITES AND SHRUB-SCRUB SONGBIRDS

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ABSTRACT

We evaluated the effect of early-successional habitat management practices on vegetation structure and composition, shrub-scrub songbird nesting, wintering songbird habitat use, and Northern Bobwhite habitat use in the lower Coastal Plain of South Carolina. The response of vegetation was measured for 18 different disturbance treatments at the end of each growing season from 2000 to 2006. The response of vegetation to disturbance was different among treatments. However, similarities existed between burn and disk treatments with the same season and frequency. We found 76 shrub-scrub songbird nests during the 2005 and 2006 nesting seasons. Painted buntings, indigo buntings, and blue grosbeaks were the most commonly found nesting species in the study. Nesting success and productivity experienced variation between years. Nest failures were the most commonly caused by storms, snakes, and raccoons. Hedgerows and field borders were the most commonly used habitat for nesting. Winter songbird use of early-successional habitat was studied in January and February of 2006. Birds were counted in treatment plots during man drives. Bird numbers were highest in plots that received spring and winter burning treatments. Northern bobwhites (n=11) were tracked using a modified homing technique from February thru August of 2006. Locations (n=951) were recorded based on the habitat type birds were in 3 times daily. Bobwhite use of the study area indicated that ditchlines, hedgerows, and food plots were important field components for the species. Based on our results land managers in the lower Coastal Plain may achieve the greatest results in early-successional habitat management with the use of prescribed burns applied in the spring at least every two years.

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CHAPTER 1

LITERATURE REVIEW

Vegetation Response to Management Practices

Disappearance of early successional habitat has caused declines in the populations of many early successional bird species (Burger 2004, Brennan 1991, Langer 1989, MacGowen 2001). The USDA Natural Resources Conservation Service (NRCS) recognized the loss of early successional habitat and the corresponding decreases in bird populations. In response, the NRCS developed guidelines for field managers to maintain early-successional habitat. This study was designed to gain information on developing and sustaining early-successional habitat, and to determine the response of vegetation to burning and disking treatments.

Management of old field habitat is generally conducted using prescribed burning, disking, mowing, or a combination of these treatments. These practices are common in the agricultural community, and are often used to clean fields after harvest and to maintain pasture lands. These management practices slow or retard plant succession. In the absence of disturbance succession will proceed and field habitat will become forested lands. These practices can be very important to early-successional bird species, such as the northern bobwhite quail (*Colinus virginianus*), painted bunting (*Passerina ciris*), indigo bunting (*Passerina cyanea*), blue grosbeaks (*Passerina caerulea*), and many other early-successional songbirds.

The response of vegetation to disturbance has been a topic of researchers for many years. Studies have shown temporary increases in the amounts of herbs, forbs, briars, and vines following a disturbance (Rideout et al. 2003, Greene 1934, Wahlenberg 1935, Heyward 1937, Oosting 1944, Lemon 1946, Cushwa et al. 1966, and Vogl 1973). Researchers in Texas report that prescribed burning may increase the abundance of annual and perennial forbs (Ruthven et al. 2002). Shrub and forb coverage was found to increase during the year following a disturbance, while grass abundance was unaffected (Ruthven and Krauker 2004).

Altering the time of year in which disturbance occurs can affect vegetation composition and structure (Ruthven et al. 2002, Kay et al. 1978). Howe (1994) reports burns applied during the dormant season produced plant communities that differed from plant communities associated with growing season burns in Southern Wisconsin. Disking in the spring and fall for agricultural purposes has encouraged agricultural weeds to evolve (Sagar 1974, Altieri 1981). When soils are disked at other times of the year the response of vegetation can be much different (Altieri 1981). Altieri (1981) found species composition varied with disturbance dates, but species diversity remained fairly constant in Northern Florida. December disking produced the highest plant biomass, and October disking dates provided the highest vegetation height during the growing season (Altieri 1981). Kay et al. (1978) reported August disk dates in Northern Florida could greatly reduce the amount of living vegetative cover in fields.

Grassland Songbirds

Many North American birds have suffered population declines over the past several decades, with grassland songbirds suffering particularly severe declines (Price et al. 1995). The North American grasslands have been disappearing at a steady rate since the arrival of early settlers. The disappearance of native grasslands has lead to population declines of species like bobolink (*Dolichonyx oryzivorus*), dickcissel (*Spiza americana*), eastern meadowlark (*Sturnella magna*), grasshopper sparrow (*Ammodramus savannarum*), and many others (Hays et al. 2002). Efforts are being made to restore this important habitat and federal assistance is available through the USDA NRCS with the Conservation Reserve Program (CRP) and WHIP (Cunningham 2000). Research has shown restored grasslands may not achieve the diversity and structure of native grasslands, but they provide similar habitat suitability for most grassland birds (Fletcher and Koford 2002). Species richness and density of grassland birds in Iowa were similar in restored and native grasslands (Fletcher and Koford 2002).

Grassland songbird populations are very fluid and experience fluctuations in population size and nesting success between years and regions (Winter et al. 2005, Cody 1985, Igl and Johnson 1997, and George et al. 1992). Research has shown that different grassland bird species have different habitat requirements and that vegetation characteristics affect species differently (Winter et al. 2005). The various niches of the grassland songbirds make it difficult to provide a simple management plan (Winter et al. 2005). In order to provide multiple species of grassland birds with the habitats they need, management requires the establishment of a mosaic of habitat components (Winter et al. 2005, Herkert et al. 1996, Dale et al. 1997, Madden et al. 2000, McMaster and Davis 2001).

Shrub-Scrub Songbirds

Early successional birds have also experienced dramatic losses over the past half century, in response to habitat losses due to changes in agricultural practices (Suarez et al. 1997). Researchers have begun to investigate nesting success of these early successional songbirds over the past 20 years. Weldon (2006) examined nesting success of indigo buntings (*Passerina cyanea*) in relation to corridors. She found corridors increased nest predation in South Carolina, and nest predation was the primary cause of nest failure along the corridors. Other research has been conducted to examine nesting success of early successional songbirds on different types of edges. Results of this research indicated nest predation rates on agricultural and abrupt edges were twice as high as the rates along gradual edges where plant succession was allowed to soften the edge (Suarez et al. 1997). The abrupt edges typical of modern agricultural fields may even serve as population sinks (Suarez et al. 1997, Ratti et al. 1988). Suraez et al. (1997) found edge habitat created by natural tree gaps provided indigo buntings with the most successful nest sites. They speculated that success was due to a lack of predator travel lanes and additional food sources, as well as the rich foraging habitat that the gaps provided the songbirds.

Northern Bobwhite Quail

The Northern bobwhite (*Colinus virginianus*) is the most widely distributed North American quail species, occurring throughout the Southern, Eastern, and Midwest portions of the U.S. The Northern bobwhite also occurs in small populations in Oregon, Washington, Idaho, and the foothills of the Rockies (Quail Unlimited 2005). Historically, the Northern bobwhite has been a very important species to the southeastern U.S. The bobwhite's famous rise in front of the bird dog's nose made it a very prestigious game species. Northern bobwhites are considered an edge favored species typically utilizing farmlands and other moderately open areas (Chumchal 1995). Early-successional stages of plant development are extremely important to the species. Ideal quail habitat provides abundant food supplies of insects and seeds, ample cover, and easy travel routes (Mahan and Carmichael 1995).

Northern bobwhite habitat requirements vary throughout the year with different needs for nesting and brood-rearing. Nesting habitat is typically fairly dense with herbaceous vegetation interspersed with saplings and shrubs. Although this habitat is dense, bareground is normally close by (Roseberry and Klimstra 1984). Brood-rearing habitat provides easy travel for young, while also offering overhead protective cover and high insect populations.

Insect availability is very important to the production of bobwhites. Protein levels in insects are around 40-50%, and insects provide methionine and cysteine, which are crucial for growth and feather development (Guthery 2000).

Broods stay with parents throughout the summer. The fall shuffle occurs at the beginning of fall with covey formation and allows family groups to be dispersed (Dimmick 1992). During the fall shuffle family groups unite and separate several times until the actual winter covey is formed. The final covey may be comprised of birds from several different family groups. Individuals will eventually stick with a covey and they will remain together throughout the winter. Covey breakup occurs at the beginning of spring as mating resumes.

Over the past half-century Northern bobwhite populations in the southeastern U.S. have experienced drastic declines (Capel et al. 1995). Populations are estimated to be decreasing at an average of 3.8 percent annually (Burger 2004). The decrease in bobwhite populations is mainly attributed to habitat loss due to changes in land-use including cleaner farming practices (Burger 2004, Brennan 1991, Langer 1989, MacGowen 2001). Past agricultural practices provided habitat for bobwhites with brushy fencerows and unplowed field borders. Cleaner farming practices, which utilize all parts of the field for crops are detrimental to bobwhites (Brennan 1991).

Vegetation Management for Bobwhites

Previous research has shown the critical importance of maintaining the appropriate successional stage for bobwhites (Ellis et al. 1969). Maintaining lands in early stages of plant succession can be achieved through mowing, burning, or disking. If the site remains undisturbed for too long, plant succession will advance to a state that becomes unsuitable for bobwhites (MacGowen 2001). Disturbances should be used to prevent trees from dominating early successional habitat. Typically, disturbances are applied on a 3-5 year basis. Maintaining the site in the appropriate successional stage maximizes the usable space for bobwhites, and thus allows bobwhite densities to increase (Guthery 1997).

Restoration of native warm-season grass stands has become an objective of many quail and songbird management programs over the past decade. This restoration comes after millions of acres across the Southeast were converted from native grasses to bermudagrass (*Cynodon* spp.) and other hay/grazing species. Sod-forming species like bermudagrass have had detrimental effects on the quality of habitat for many wildlife species. The dense matting typical of these species is not suitable for nesting, brood-rearing, feeding, or traveling (Hays et al. 2002). Native warm-season grasses are in general bunchgrasses that produce relatively open travel lanes between plants. These open travel lanes allow forbs to grow and produce food for grassland birds. Bunchgrasses also produce suitable overhead cover for protection from avian predators (Hays et al. 2002).

Changes in the southeastern farming practices have removed hedgerows that were once common in agricultural landscapes (Brennan 1991). These hedgerows divided fields and provided protective travel corridors for bobwhites. Hedgerows also provide bobwhites with essential winter food resources and protective cover (Stoddard 1931). The United States Department of Agriculture's Natural Resources Conservation Service (USDA NRCS) recognized this loss of habitat and has included hedgerow development and maintenance into its Wildlife Habitat Incentives Program (WHIP) plans across the Southeast. WHIP plans require hedgerows to be established using woody species or bunchgrasses that reach at least 3 feet tall (NRCS 2003). Hedgerows are also required to be at least 15 feet in width at maturity, and offer cover which persist over the winter (NRCS 2003). Several different plant species can successfully meet these requirements and provide the habitat needed by bobwhites and other species. Big Bluestem (*Andropogon gerardii*), Little Bluestem (*Schizachyrium scoparius*), Eastern Gamma grass (*Tripsacum dactyloides*), and Indiangrass (*Sorghastrum nutans*) are several of the native warm-season grasses that can be used to create hedgerows. Perennial shrub hedgerows can also be created with species like Thunburg Lespedeza (*Lespedeza thunburgii*), which provide quality food, travel, and cover.

Study Goals

The NRCS has developed guidelines for developing early-successional and grassland habitats recognizing the decline in these habitats and their importance to many bird species. However, few studies have monitored these management practices over beyond 1 or 2 growing seasons to assess their long-term benefits and examine managements issues associated with sustaining these habitats.

Our study was designed to evaluate the effect of recommended field management practices, which had been in place for 6 growing seasons at the end of the study, on bobwhites and songbirds in the lower Coastal Plain of South Carolina. The main objectives of the study were to: 1) determine temporal changes in vegetation structure and composition in response to management practices; 2) determine nest site selection, nesting success, and productivity of songbirds using abandoned agriculture fields within the study area; 3) determine which techniques for managing early-successional habitat are preferred by wintering songbirds; and 4) determine habitat use within study fields by bobwhites.

CHAPTER 2

VEGETATION STURCTURE AND COMPOSITION IN RESPONSE TO FIELD MANAGEMENT

Abstract

We evaluated the effect of early-successional habitat management practices on vegetation structure and composition in the lower Coastal Plain of South Carolina. The response of vegetation was measured for 18 different disturbance treatments at the end of each growing season from 2000 to 2006. Vegetation height was different between treatments. Burning every third spring produced the tallest vegetation and disking every spring produced the lowest vegetation heights. Ground cover variables differed between treatments. Grass cover was greatest in plots that received annual spring disking. Disking every other year in the winter produced the greatest amount of forb ground cover. Herbaceous species composition was different between treatments. Species richness was greatest in plots receiving annual summer burns. Woody stem density differed between treatments and was highest in triennial summer burn plots. Our results indicate the response of vegetation to disturbance was different among treatments. However, similarities existed between burn and disk treatments with the same season and frequency. Land managers in the lower Coastal Plain are encouraged to use prescribed burning to maintain early-successional habitat. When fire is not an option, disking may provide similar results.

Introduction

Most studies have examined the response of vegetation to disturbances for low 2 year post treatment, but few have monitored impacts over several growing seasons. This information is needed to develop best management practices for sustaining early-successional habitats. Further, little is known about vegetative response in relationship to season or frequency of treatments. Common row cropping practices have forced weeds to evolve with spring and fall disking practices in agriculture settings (Altieri 1981, Sagar 1974). Vegetative response to disking can be very different when soils are disked at times atypical of agriculture practices (Altieri 1981). Species composition and total plant biomass can be effected by altering the time of disturbance (Altieri 1981). Ground cover can be altered with changes in disturbance dates (Kay et al. 1978). Vegetative characteristics change in response to disturbance and continue to change temporally. Hodgkins (1958) reported the growing season immediately following a fire was dominated by grasses and forbs, but the vegetation of the next growing season was dominated by grasses and woody plants. Research conducted in the Coastal Plain of the Southeastern United States indicated fire frequency is more important than fire season in maintaining species diversity (Streng et al. 1996). The exact changes to species composition and structure are still unclear for the Coastal Plain of South Carolina.

Study Area

This study was conducted at Nemours Plantation, which is operated by Nemours Wildlife Foundation (NWF). The NWF was established in 1995 by Eugene DuPont III and family. NWF is a private 501(c)(3) operating foundation and is administered by a board of directors. Primary focuses of the foundation include: research, education, and stewardship of natural resources.

Nemours Plantation is a 4,000 ha track of land located in Beaufort County, South Carolina. The plantation lies within the Ashepoo-Combahee- Edisto (ACE) River Basin, which is located in the lower Coastal Plain, and has been designated as one of the last great places on earth by The Nature Conservancy. The plantation contains a diverse assemblage of habitats including remnant rice fields, fresh and brackish marshes, pine savannahs, upland pine and hardwood forests, bottomland hardwood forests, cypress/tupelo swamps, maritime forests, and abandoned agriculture fields.

The study area had a relatively long growing season. Green-up typically occurs in March and the growing season runs into October producing a 8 month growing season. Annual rainfall averages 123.2 cm for the study area. Moderate to poorly drained sandy clay soils dominated the study area.

The study area was approximately 400ha, and consisted of 14 fields and their associated woodlands. Field size ranged from approximately 0.4 ha to 22.7ha (ξ = 7.5 ha). These fields were known to have been planted in agricultural crops for the past 3 decades and likely used in agricultural practices for the past several centuries. Prior to the abandonment of agriculture practices, the fields had been used for row cropping (corn/soybean) and pasture for dairy cattle. Fields used in this study were under management practices for early-successional habitat from 2000 to 2006.

Study Design

Field management practices were applied across a matrix of 10 abandoned agricultural fields, which were subdivided into smaller treatment plots to create a split-plot design. Treatment plots (n=109) were randomly assigned a treatment, season, and frequency. Treatments assigned were burning or disking. Seasons were defined as spring, summer, and winter. Spring was defined as the months of March and April. Summer was defined as May through October, and winter was defined as November through February. Seasons were established in this manner to accommodate the climate and long growing seasons associated with the lower Coastal Plain. Combining treatment, season, and frequency created 18 different treatments. Each treatment was assigned to at least 3 of the 109 possible plots. Treatment applications began in January of 2000.

Fields also contained native warm-season grasses, hedgerows, and field borders. Warm-season grass plots (n=14) were established in 4 of the fields during the 2000 growing season. These grass plots were seeded with big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Illinois bundle flower (*Desmanthus illinoensis*), and maximilian sunflower (*Helianthus maximiliani*). Once established, these plots were maintained with spring burns. Plateau® herbicide was used to reduce the competition of broad-leafed forbs and release native warm-season grasses. Hedgerows were planted with Thunberg Lespedeza (*Lespedeza thubergii*) in each field during the 2000 growing season. The hedgerows were fertilized in the spring with a low/no nitrogen fertilizer and maintained with prescribed burns as needed. Field borders, 10-30 m in width, occurred around the edges of fields and sub-divided treatment plots within large fields. Field borders were maintained with periodic prescribed fire and spot treatment with herbicide to manage woody encroachment.

Methods

The response of vegetation to treatments was assessed by collecting measurements of vegetation structure and composition. Measurements were collected in every plot at the end of the growing season (October-November) from 2000-2006. Transects with random starting points were walked in each plot. Sample plots were established approximately 25 m apart along the transect. At each sample plot, measurements were taken for vegetation height, ground cover classification, species composition, and woody stem density. Vegetation height was measured in four cardinal directions using a robel pole (Robel et al. 1970). Ground cover was measured twice at each sample plot using a Daubenmire frame (20 cm x 50 cm) (Daubenmire 1959, Higgins et al. 1996). Percentage of grass, forbs, woody plant species, soil, and debris coverage of the frame area was estimated. Individual species and their percent coverage were also estimated. A center point was established and all woody stems within an 8 m radius were recorded.

Analysis

Vegetation measurements collected during this study were analyzed using Statistical Analysis System (SAS) (SAS Institute, Inc., © 2003). Vegetation height, ground cover, species composition, and woody stem density were analyzed. The means procedure was used to obtain means for all measured vegetation variables by the treatments they were collected in and by years. Vegetation variables were also analyzed with an analysis of variance (ANOVA) to determine if differences between the treatments and years existed. Vegetation variables were analyzed using a T-test for Least Square Difference (LSD) to determine if there were differences in vegetation variables between treatments. We hypothesized that vegetation characteristics measured in this study would differ between treatments. Hypothesis were tested at the α=0.10 level.

Results

Vegetation Height

Mean vegetation height for treatments differed ($p \leq 0.0001$) and ranged from 14 to 29 cm. Burning every third spring resulted in the tallest vegetation height, while disking biannually in the spring produced the shortest mean vegetation height (Fig. 2.1-3). T-tests conducted on LSD indicated that similarities existed between disturbances that had the same season and frequency. Disking and burning produced similar vegetation heights for all seasons and frequencies, except for biannual frequencies. Biannual disturbance frequencies yielded different vegetation heights between burn and disk treatments for all seasons.

Mean Grass Ground Cover

Annual Treatments

Mean grass ground cover was different between treatments throughout the study (2000 p = 0.0320, 2001 p = 0.0004, 2002 p = <0.0001, 2003 p = <0.0001, 2004 p = 0.0102, 2005 p = 0.0057, and 2006 p = 0.0002). Mean grass cover differed between treatments, but there were similarities within years. In several years similarities were detected in seasons between treatments. Burning and disking in the winter provided similar mean grass cover in 2001, 2002, and 2006. Spring treatments were similar in 2003, 2004, and 2006. Summer treatments produced similar mean grass ground cover in 2003.

Grass levels fluctuated from year to year within a treatment (Figure 2.4). Mean grass cover was at its highest levels at the beginning of the study for all treatments. Grass cover exhibited a rise and fall pattern from year to year for all treatments. Mean grass cover for all treatments had decreased for all treatments at the end of the study. Burning in the spring annually caused the greatest decrease in mean grass coverage, approximately 38% from 2000 to 2006. Disking in the spring annually caused the least decrease (6%) in mean grass cover from 2000 to 2006.

Biannual Treatments

Mean grass ground cover was similar for all treatments in the beginning of the study (p = 0.5407). Mean grass cover was different between treatments during the remainder of the study (2001 p = 0.0001, 2002 p = <0.0001, 2003 p = <0.0001, 2004 p =

<0.0001, 2005 p = <0.0001, and 2006 p = <0.0001). In 2003, similarities were detected in mean grass levels in burn spring 2 and disk spring 2 treatments. Mean grass levels in burn summer 2 and disk summer 2 treatments were similar in 2005 and 2006.

Mean grass levels experienced fluctuation from year to year, and exhibited a rise and fall pattern between years (Figure 2.5). Burn winter 2 was the only treatment to experience an increase in the amount of mean grass ground cover, rising approximately 6%. At the end of the study grass levels were highest in burn winter 2, disk spring 2, and disk summer 2 treatments. The greatest decrease (27%) in mean grass levels occurred in disk winter 2 treatments.

Triennial Treatments

Mean grass cover was similar between all treatments in 2001 (p = 0.2025) and 2002 (p = 0.9588). Mean grass cover differed between treatments in 2000 (p = 0.0002), 2003 (p = <0.0001), 2004 (p = 0.0752), 2005 (p = <0.0001), and 2006 (p = 0.0170). Disk winter 3 and burn winter 3 treatments produced similar amounts of grass cover in 2001, 2002, 2003, 2004, and 2006. Disk spring 3 and burn winter 3 treatments had similar grass ground cover in 2001, 2002, 2004, and 2006. Burn summer 3 and disk summer 3 treatments produced similar amounts of grass cover in 2001, 2002, 2004, and 2006.

Maximum grass cover was reached at different years between treatments (Figure 2.6). Overall mean grass cover increased for only one treatment. Grass cover in burn summer 3 plots increased 15% during the study. Grass levels in all treatments experienced increases above original levels during the study, but final levels of grass cover had decreased below original measures. The greatest decline (19%) in mean grass cover was experienced in plots treated with triennial spring disking.

<u>Mean Forb Ground Cover</u>

Annual Treatments

Mean forb ground cover was different between annual treatments for all years of this study (2000 $p = 0.0042$, 2001 $p = <0.0001$, 2002 $p = <0.0001$, 2003 $p = <0.0001$, 2004 $p = 0.0002$, 2005 $p = 0.0122$, and 2006 $p = 0.0019$). Several years produced similarities between a few treatments. Burn winter 1 and burn spring 1 produced similar amounts of forbs in 2000. Burn winter 1 and disk winter 1 treatments produced similar amounts of forb ground coverage in 2002, 2003, 2005, and 2006. Burn spring 1 and disk spring 1 had similar amounts of grass ground coverage in 2002, 2003, and 2005. Burn summer 1 and disk summer 1 treatments produced similar forb ground coverage in 2002 and 2005.

When plotted, forb ground cover in annual treatments slightly exhibited a positive bell shaped curve (Figure 2.7). All treatments exhibited their lowest level of mean forb ground cover at the beginning of the study. Forb ground cover reached maximum levels for most treatments in the 2004 or 2005 growing seasons. Forb ground cover decreased from maximum levels for all treatments during the 2006 growing season. Mean forb ground cover increased (34%) the most for the burn spring 1 treatment. Burn summer 1 and disk spring 1 provided the least overall increase (6%) in forb ground cover.

Biannual Treatments

Mean forb ground cover was similar between all treatments at the beginning of the study (p = 0.6774). Forb cover differed between treatments for the remainder of the study (2001 p = <0.0001, 2002 p = <0.0001, 2003 p = 0.0019, 2004 p = <0.0001, 2005 p = <0.0001, and 2006 p = 0.0031). Disk winter 2 and burn winter 2 produced similar amounts of forb ground cover in 2002. Burn spring 2 and disk spring 2 were similar in 2006. Forb ground cover was similar between burn summer 2 and disk summer 2 in 2006.

Forb ground cover exhibited a rise and fall pattern between years for all treatments (Figure 2.8). Forb cover reached maximum levels for all treatments during the 2004 and 2005 growing season. Forb cover levels decreased after reaching maximum levels. All treatments experienced an overall increase in forb ground cover. The greatest increase (11%) in forb ground cover occurred in the burn spring 2 treatment. Mean forb ground cover increased the least (1%) in the disk winter 2 treatment.

Triennial Treatments

Mean forb ground cover was similar between all treatments in 2001 (p = 0.1699), 2002 (p = 0.8261), and 2006 (p = 0.5394). Forb cover differed between treatments in 2000 (p = 0.0030), 2003 (p = <0.0001), 2004 (p = 0.0407), and 2005 (p = <0.0001). At the beginning of the study burn winter 3 and burn spring 3 had similar levels of forb cover. Burn winter 3 and disk winter 3 were similar in 2003, 2004, and 2005. In 2004, burn spring 3 and disk spring 3 had similar forb ground cover. Burn summer 3 and disk summer 3 were also similar in 2004.

Mean forb ground cover exhibited a bell shaped curve for all treatments excluding burn spring 3 and disk summer 3 (Figure 2.9). Burning in the spring and disking in the summer produced forb levels that appeared to rise and fall between growing seasons. All treatments reached maximum forb cover levels between the 2003 and 2005 growing seasons. Forb cover experienced an overall increase in all treatments except burn summer 3 and disk winter 3. The greatest increase in forb cover (6%) occurred in the burn spring 3 treatment. Forb cover decreased the most (23%) in the disk winter 3 treatment.

Herbaceous Species Composition

Herbaceous species composition was different between years ($p \leq 0.0001$). Composition was different between treatments ($p \leq 0.0001$) (Table 2.3). Composition differed by years within a treatment ($p = 0.0002$). Grass species composition ranged from 5 to 15 species and was different between treatments ($p \leq 0.0001$). The maximum number of grass species (n=15) was found in plots burned every other spring. The fewest grass species were found in field borders and plots disked every third spring (n=4 and n=5, respectively).

The frequency of broomsedge (*Andropogon virginicus*) occurrence increased for all treatments as time elapsed (Fig. 2.10-13). At the beginning of the study broomsedge was rare in all treatment plots. Winter burns produced frequent occurrences of broomsedge. Broomsedge was lowest in plots receiving a spring disking treatment.

Crabgrass (*Digitaria* spp.) occurrence increased for all treatments during the first half of the study (Fig. 2.13-15). Levels appeared to max out during the 2003 and 2004 growing seasons. After maxing out, crabgrass levels declined steeply. Crabgrass levels at the end of the 2006 growing season were lower than initial levels.

Panicgrass (*Panicum* spp.) occurrence fluctuated between years for all treatments (Fig. 2.16-18). Initial and final levels of panicgrass were similar for most treatments. Summer disking consistently produced high levels of panicgrass.

Forb species composition ranged from 8 to 39 species and was different between species ($p \leq 0.0001$). Forb species composition was greatest in plots disked or burned annually in the summer (n=39 and n=36, respectively). The lowest forb species composition was found in field borders (n=8). Spring disking treatments yielded lower numbers of forb species than other treatments (annual=21, biannual=23, and triennial=21).

Rattlebox (*Crotalaria spectabilis*) occurrence fluctuated between years. The majority of treatments exhibited a rise and fall pattern between years (Fig. 2.19-21). Summer treatments produced high levels of rattlebox throughout the study. Rattlebox occurrence was lowest in plots that were treated with annual winter disking.

Ragweed (*Ambrosia artemisiifolia*) occurrence exhibited slight changes from year to year (Fig. 2.22-24). Overall, there was little or no difference in initial and final ragweed occurrence. Ragweed occurrence was highest in plots that were treated with annual spring burns. Ragweed increased by 31 occurrences in the annual spring burn treatment.

Dewberry (*Rubus* spp.) occurrence increased for most treatments (Fig. 2.25-27). Summer disking consistently produced the highest occurrences of dewberry. Spring treatments produced low levels of dewberry. Annual spring burning held dewberry at levels lower than all other treatments.

Woody species composition ranged from 0 to 5 species. The greatest number of woody species (n=5) were found in plots that were burned every other summer. Four treatments indicated 0 woody species: 1) burn every third summer, 2) disk every other spring, 3) disk every third spring, and 4) disk annually in the summer.

Overall species richness ranged from 14 to 58 and was different between treatments ($p \leq 0.0001$). The greatest species richness was found in plots burned annually in the summer. Species richness was lowest in field borders that were burned as needed to control woody encroachment. Spring disking dates yielded low overall species richness (annual=32, biannual=34, and triennial=27). During this study we identified 24 grass species, 48 forb species, 6 species of vines, and 19 woody species (Table 2.3).

<u>Woody Stem Density</u>

Woody stem density was found to be different between treatments (Table 2.4) ($p \leq 0.0001$). Mean stem density ranged from 3 to 8 stems per stop, or 150 to 400 stems per hectare. Stem density was highest in plots burned every third summer. The lowest stem density was found in plots disked annually in winter.

T-tests for LSD indicated that there were similarities between some treatments. Similarities were observed between burn and disk treatments with the same season and frequency of disturbance. Spring disturbances were similar among each frequency. Likewise, winter disturbances produced similar woody stem densities for each frequency. Summer disturbances only produced similarities in treatments that had an annual frequency.

Discussion

Vegetation Height

The analysis of vegetation height provided results that were contrary to the findings of Altieri (1981). Altieri found that vegetation height was greatest in plots that were treated with October disk dates. Our results indicate that spring burning produced the greatest vegetation heights. Contradiction found in the results of these studies suggests that factors other than disturbance date may impact vegetation heights.

Vegetation was tallest in plots treated with fire every third spring. Burning every third spring allowed vegetation to grow for three full growing seasons. While spring burning yielded tall vegetation heights, spring disking yielded some of the lowest vegetation heights recorded. Spring burns may have produced tall vegetation heights due to the release of nutrients at the start of the growing season.

Summer burns were extremely difficult to perform on the study site due to wet conditions, high humidity, and dense coverage of green foliage. Consequently vegetation in plots assigned to be burned during the summer may not have been treated if adequate burning conditions did not exist. In the lower Coastal Plain of South Carolina summer burns may be a poor management technique for maintaining early-successional habitat.

Grass and Forb Ground Cover

Grass cover may be an important component to early-successional habitat management for Northern bobwhites and early-successional songbirds. Many grass species provide birds with valuable food supplies and cover (Miller and Miller 2005). Our results indicate that disturbances decrease the amount of grass ground cover in fields over time. At the end of the study mean grass ground cover in fields was highest for plots that were treated with annual spring disking. Further investigation is needed to determine if grass ground cover levels continue to decrease or how long it takes grass cover to return to the original levels.

Forb cover in early-successional habitat is a component desired by land managers. Many forbs provide valuable food supplies to a variety of wildlife species. Many bird species benefit from insects that are associated with forbs. Early-successional bird species also benefit from cover provided by forbs. Our results indicated forb ground cover increased for most treatments during the 6 year study. Land managers in the lower Coastal Plain of South Carolina can expect forb cover to max out after 4-5 years. Land managers who desire to create habitat dominated by forbs will benefit from using prescribed burns applied during the winter every other year.

Grass and forb ground cover was different among treatments for most years. While treatments varied in ground cover, there were similarities within most years. We observed similarities between disking and burning treatments, with the same season and frequency, during several different years. Similarities found between disturbance types provide useful information to land managers in the lower Coastal Plain.

Burning is more cost effective than disking, and is generally less labor intensive. Prescribed burning is a great management tool, but it is not always and option. Smoke can be a major problem when roads or development is nearby. Burning may also be prohibited due to poor burning conditions, which are often experienced in the lower Coastal Plain. Our results indicate that land managers can use disking as a management tool when prescribed burning is not possible and get similar results in vegetation ground cover.

Herbaceous Species Composition

Herbaceous species composition was found to be different among treatments, different among years, and different among years within a treatment. Altieri (1981) reported in Northern Florida species composition varied with treatment date, but species diversity remained constant across treatment dates. In our study species composition also differed with treatment date, but our results indicated diversity may have also been affected by treatment date. Diversity of herbaceous species within fields may be important to bobwhite and songbird management. Greater diversity of herbaceous species may provide additional niches of the many species of birds that use old field habitat and increase the diversity of bird species present (Powell and Steidel 2000, Rice et al. 1984, and Strong and Bock 1990). Treatments applied on a three year frequency had lower species richness than the one and two year treatment frequencies. Disturbances should be applied at least every two years to maximize species diversity within fields. The results of this study indicate land managers should avoid the use of spring disking as a management tool, due to low species richness experienced in these treatments.

Herbaceous species composition was different from year to year and from treatment to treatment. Treatments with annual and biannual frequencies encouraged the growth of beneficial species such as broomsedge (*Andropogon virginicus*), partridge pea (*Chamaechrista fasciculate)*, pearl millet (*Setar glauca*), ragweed (*Ambrosia artemisiifolia*), and other plant species. Unfortunately, beneficial plants were out competed by such as dewberry (*Rubus* spp.), rattlebox (*Crotalaria spectabilis*) , bermuda grass (*Cynodon dactylon*), and other less desirable species. The thick matting behavior of dewberry and Bermuda grass make it nearly impossible for other species to compete. The huge seed bank of rattlebox was apparent as it was present in every treatment in this study. Rattlebox quickly leafed out and shaded out competitors. In most of the fields there were areas completely dominated by dewberry or rattlebox. Management practices utilized in this study may need to be supplemented with on spot herbicide treatments to control these undesirable species.

Future research is needed investigate the use of herbicides as a management tool for sustaining early-successional habitat. Studies should focus on determining which herbicides work best for releasing desired species from the competition of undesired species.

Woody Stem Density

Analysis of woody stem density data found burning every third summer provided the highest woody stem densities of all treatments. Woody stem density may have been higher in this treatment due to the difficulty of implementing a prescribed burn during the summer in the lower Coastal Plain. Woody stems in summer burn treatments may have gone undisturbed throughout the duration of this study.

Stem density was lowest in plots that were disked annually in the spring. Woody stems may have been prevented from becoming established in these plots due to disturbance at the beginning of each growing season. Spring disking dates for all frequencies yielded low woody stem densities.

Originally, it was anticipated that woody stem density would be higher in plots that were burned due to the resistance of some species to fire. Our results indicate this assumption to be inaccurate. In this study, woody stem density was affected by time and frequency of treatment, rather than disturbance type.

Summary

Field management practices created differences in the vegetative structure and composition of study fields. Management practices are used to prevent the domination of woody species while maintaining a diverse assemblage of grass and forb species. The results of this study indicate burning every third summer may be the least effective of all treatments at controlling the domination of fields by woody species. The treatment found to be the most effective at controlling woody stem density was annual spring disking. The long growing season and high annual rainfall typical of the lower Coastal Plain encourages tree growth and may require disturbances to be applied more frequently than every 3 years.

Species richness was greatest in plots that were burned either annually or biannually in the spring or summer. Spring and summer annual and biannual burns provided a diversity of vegetation characteristics that may be very valuable to bobwhite management. These characteristics include: relatively tall vegetation height, high coverage and richness of grass and forbs, a moderate amount of bare ground, and a moderate amount of woody stems. The use of spring burns for early-successional habitat management may be more effective than summer burns in the lower Coastal Plain due to the difficulty of conducting a summer burn. Growing conditions in the lower Coastal Plain require landowners to apply disturbances at least every two years to maintain early-successional habitat dominated by grasses and forbs. Disturbance frequencies longer than two years will allow woody species to out compete desirable grasses and forbs.

Figure 2.1: Mean vegetation height (cm) in spring disturbance treatments.

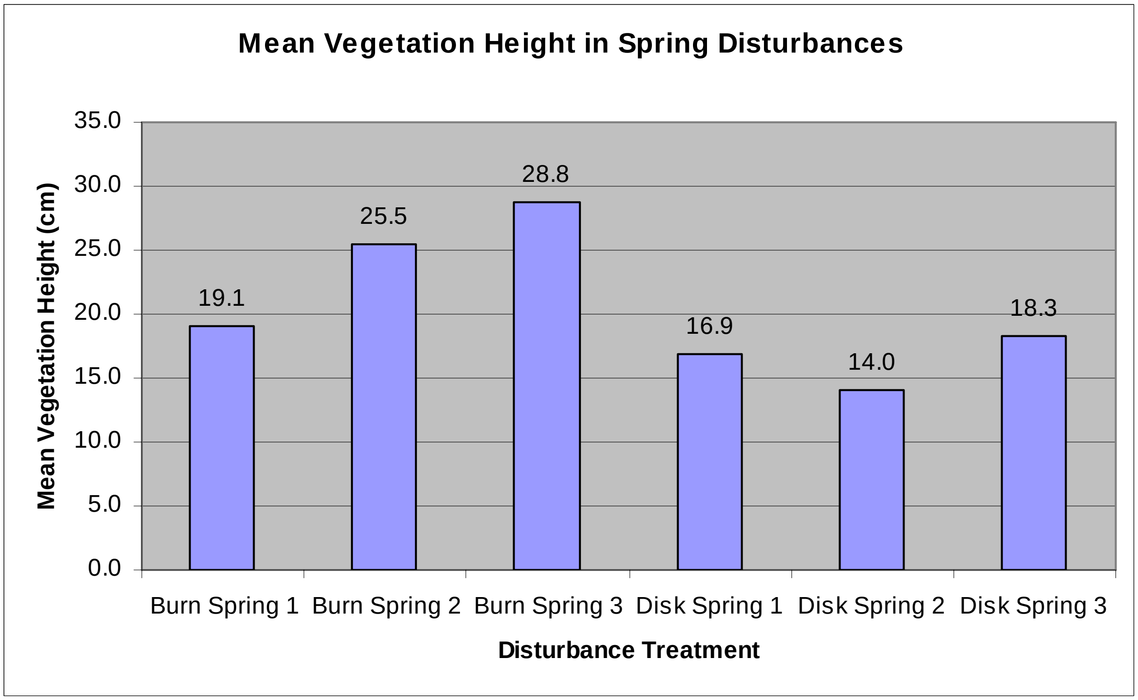

Figure 2.2: Mean vegetation height (cm) in summer disturbance treatments.

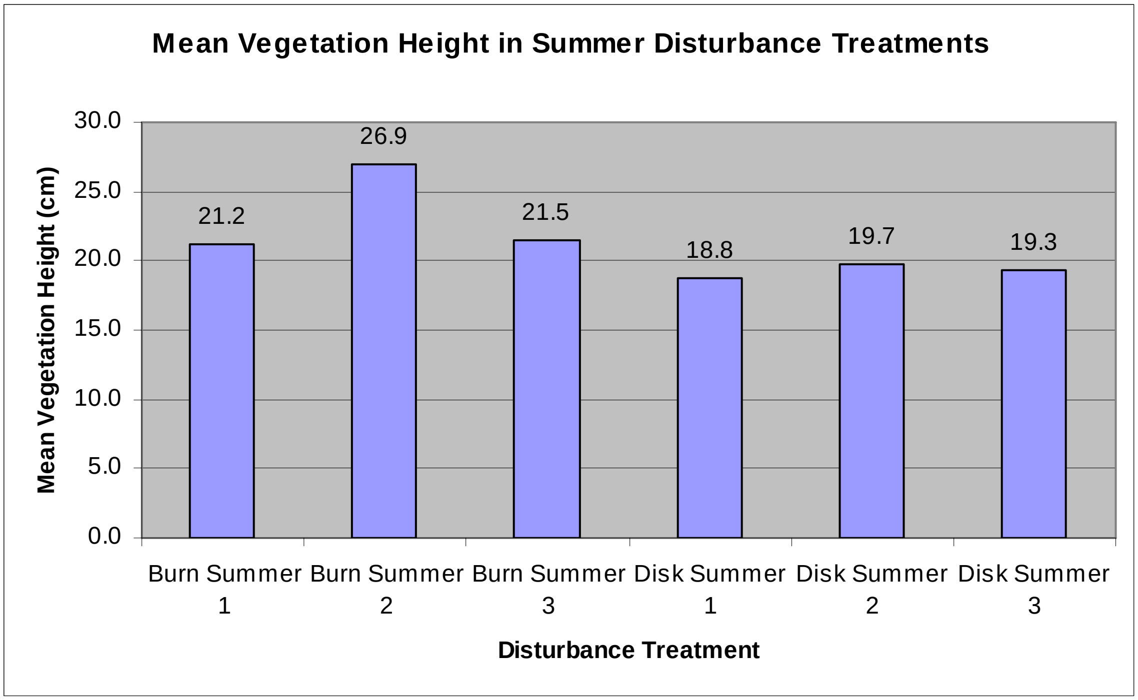

Figure 2.3: Mean vegetation height (cm) in winter disturbance treatments.

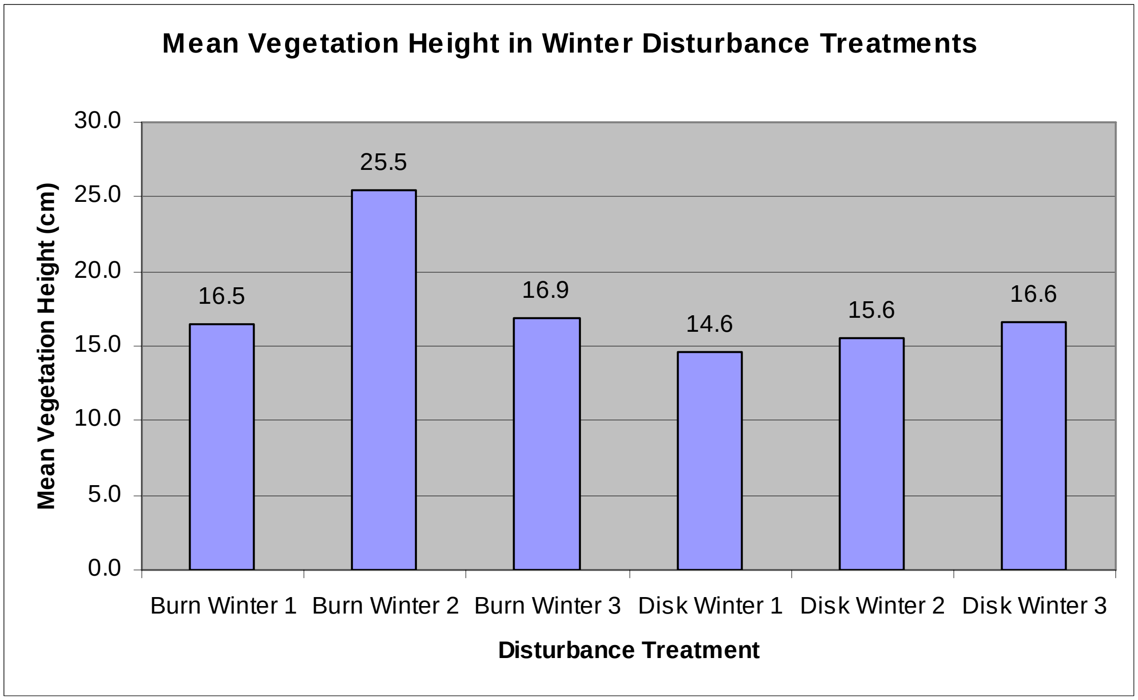

Figure 2.4: Mean grass ground cover percentage in annual disturbance treatments plotted over time.

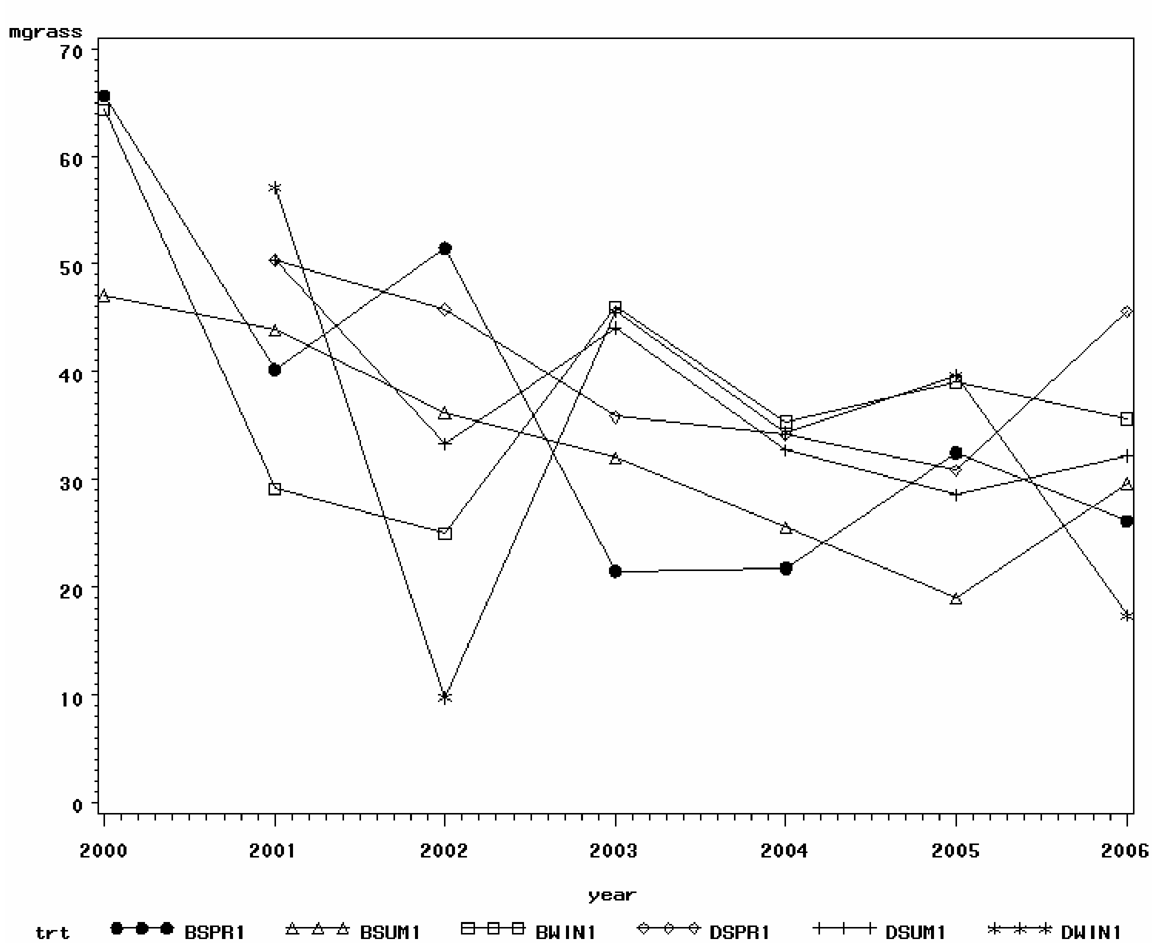

Figure 2.5: Mean grass ground cover percentage for biannual disturbance treatments plotted over time.

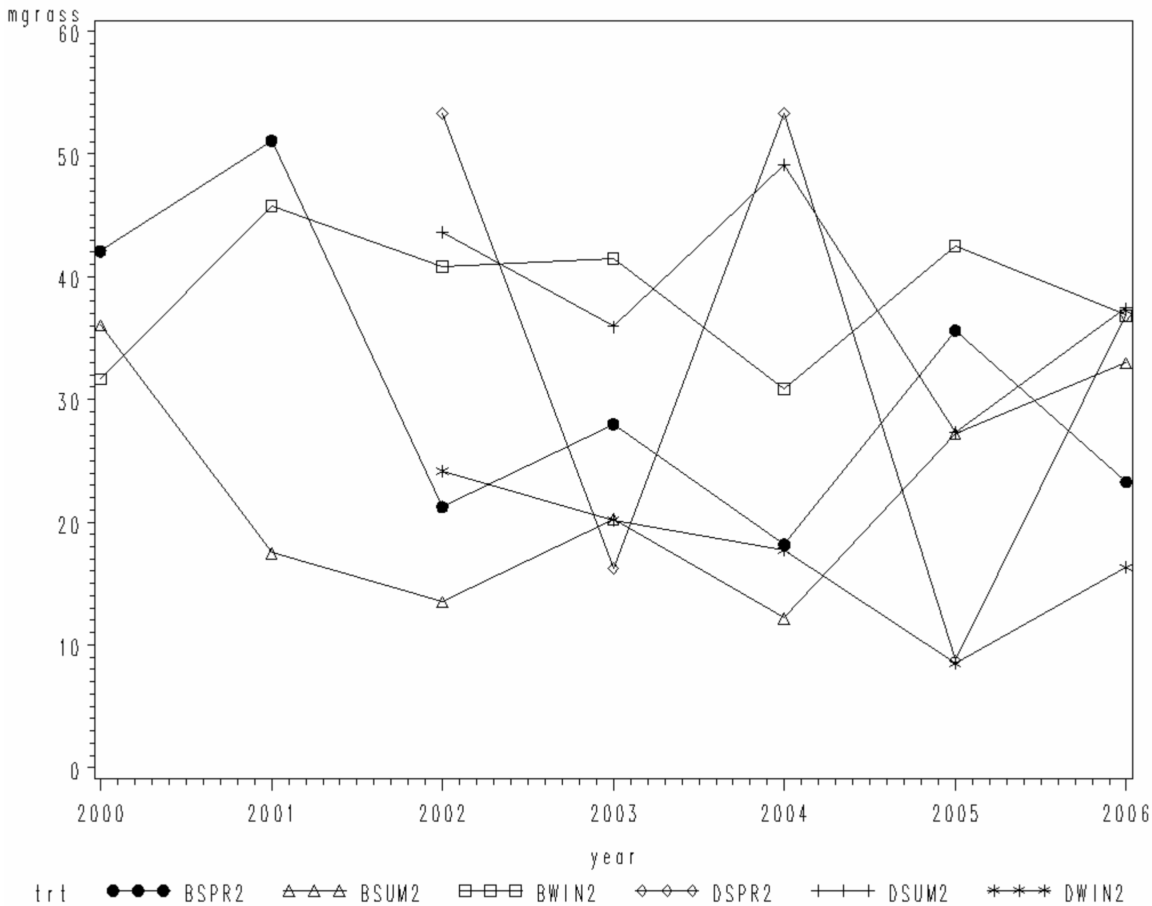

Figure 2.6: Mean grass ground cover percentage in triennial disturbance treatments plotted over time.

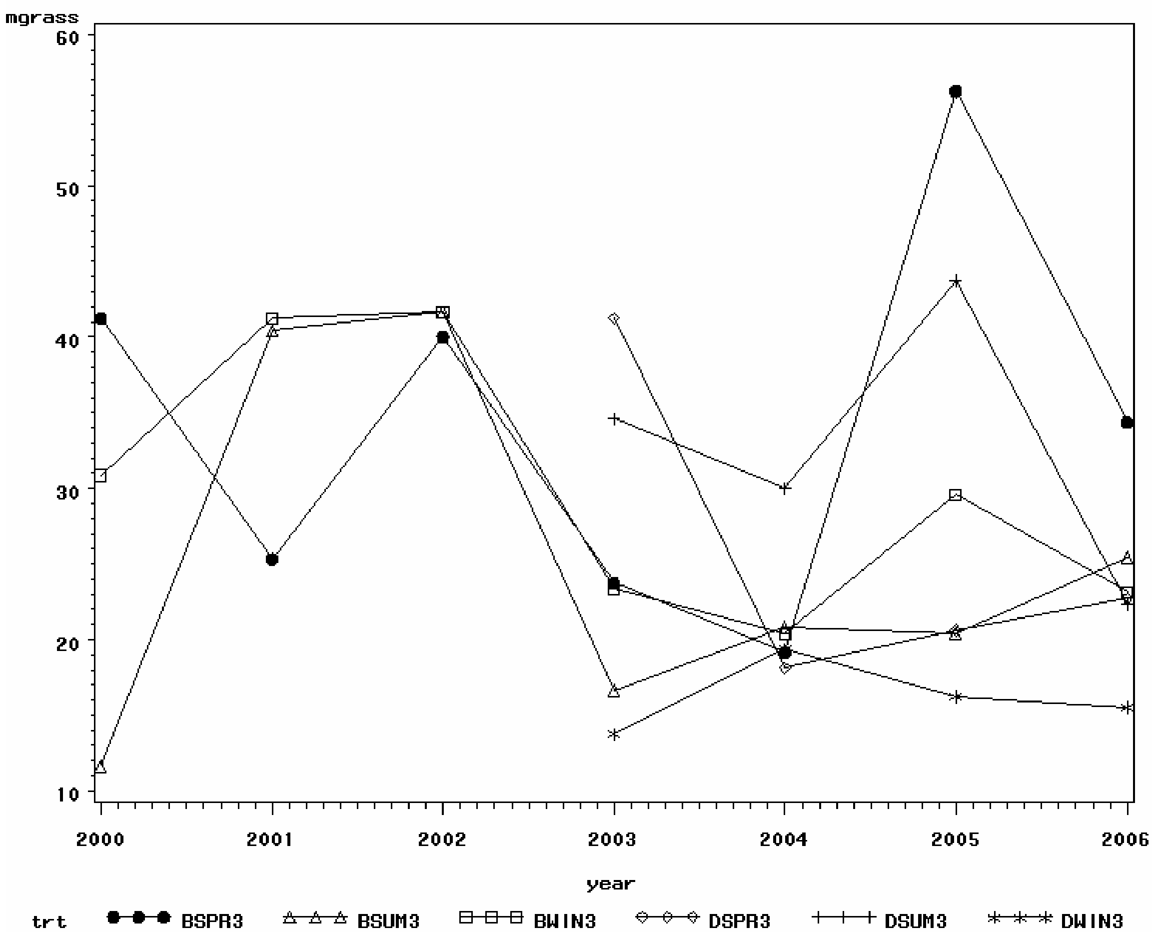

Figure 2.7 : Mean forb ground cover percentage for annual disturbance treatments plotted over time.

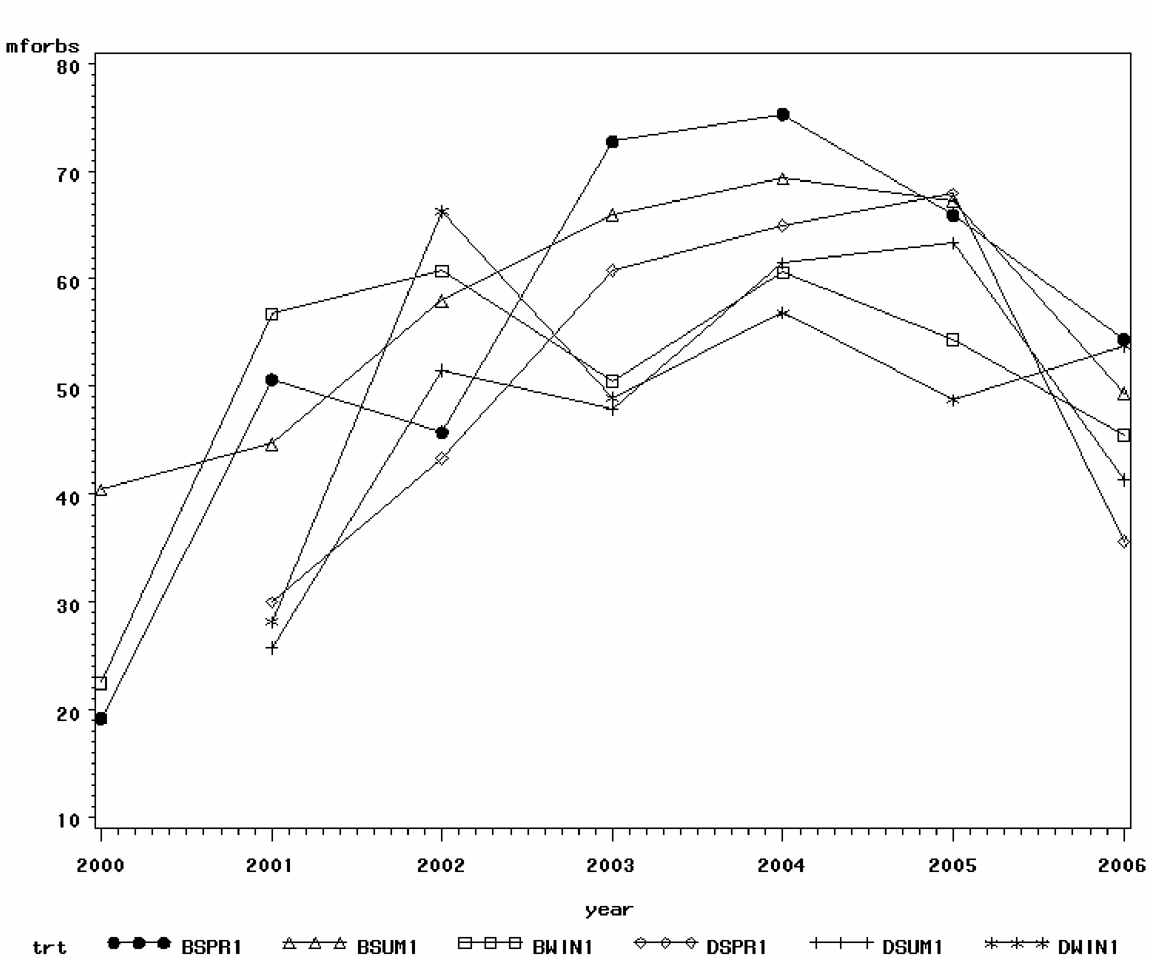

Figure 2.8: Mean forb ground cover percentage for biannual disturbance treatments plotted over time.

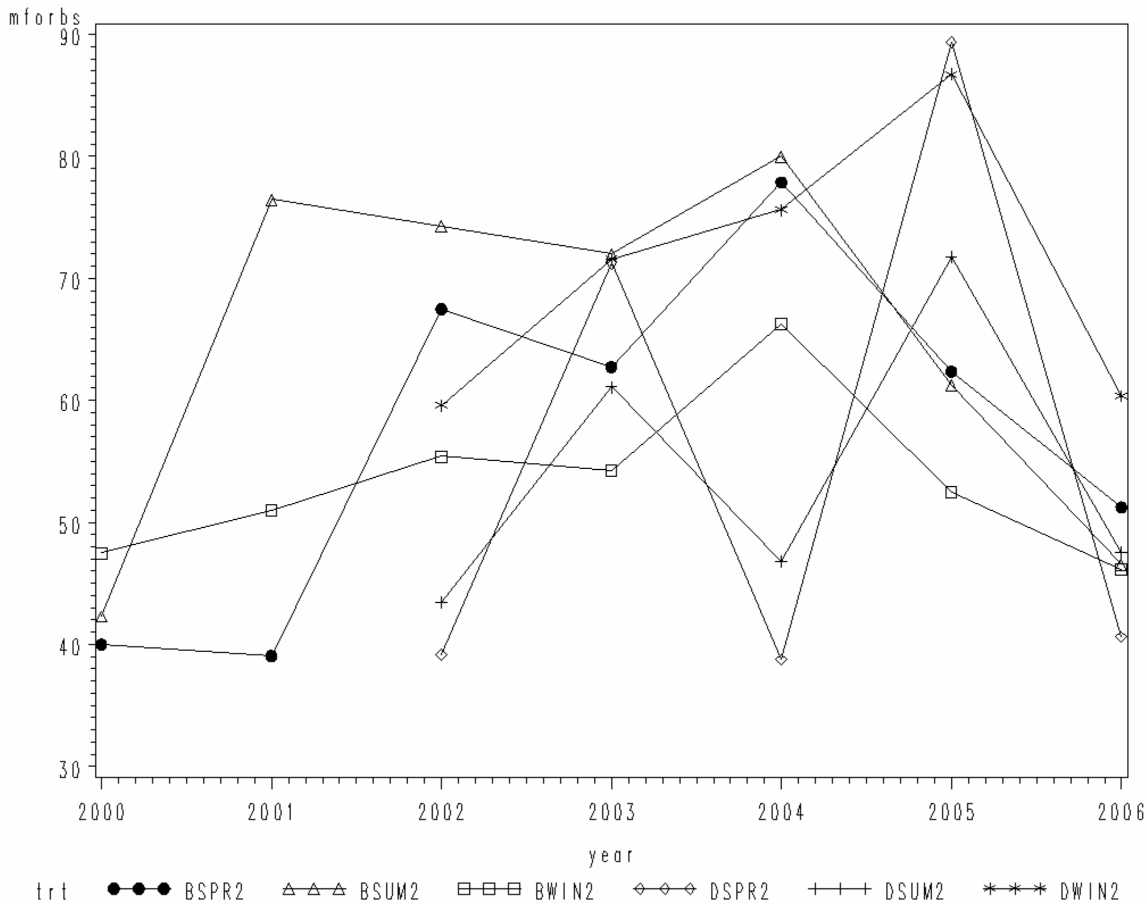

Figure 2.9: Mean forb ground coverage in triennial disturbance treatments plotted over time.

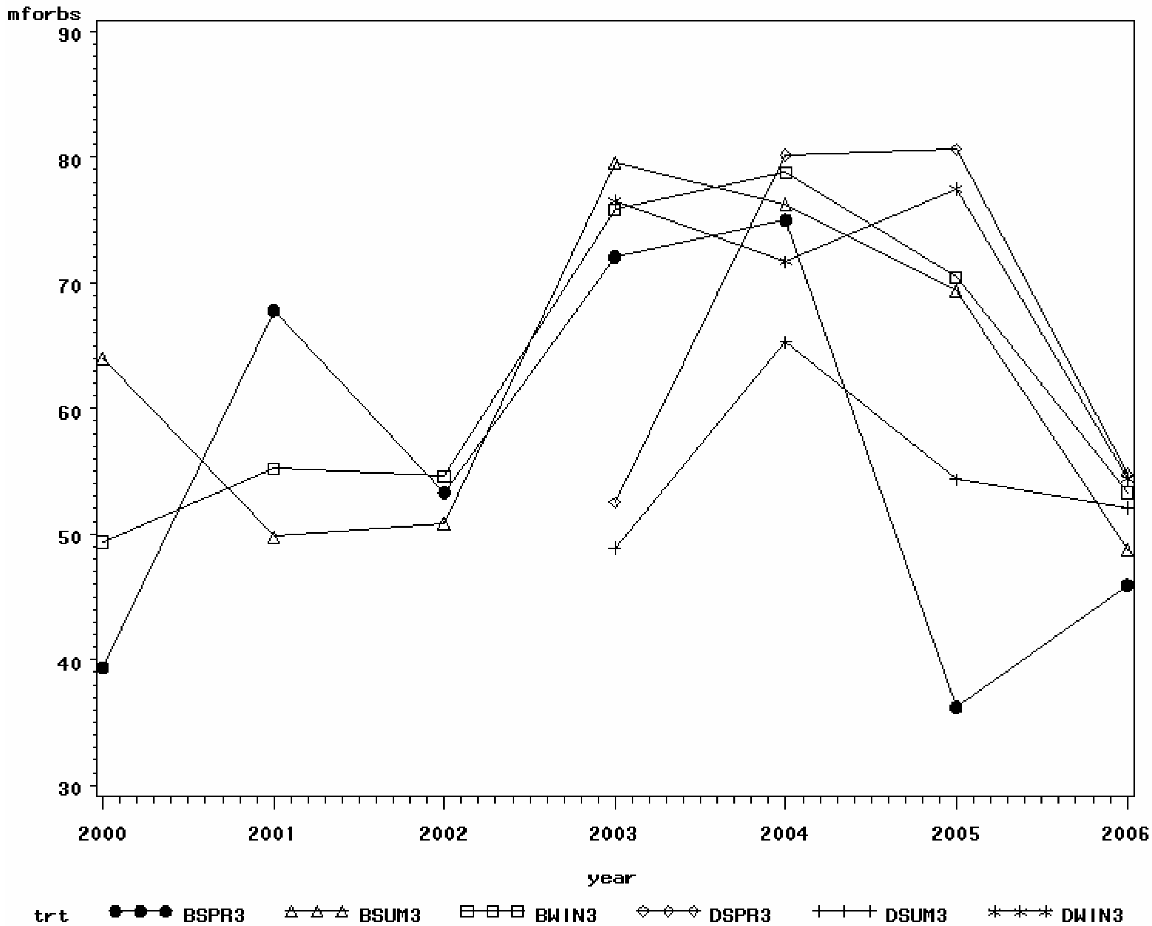

Figure 2.10: Mean broomsedge (*Andropogon virginicus*) occurrences in annual disturbance treatments over time.

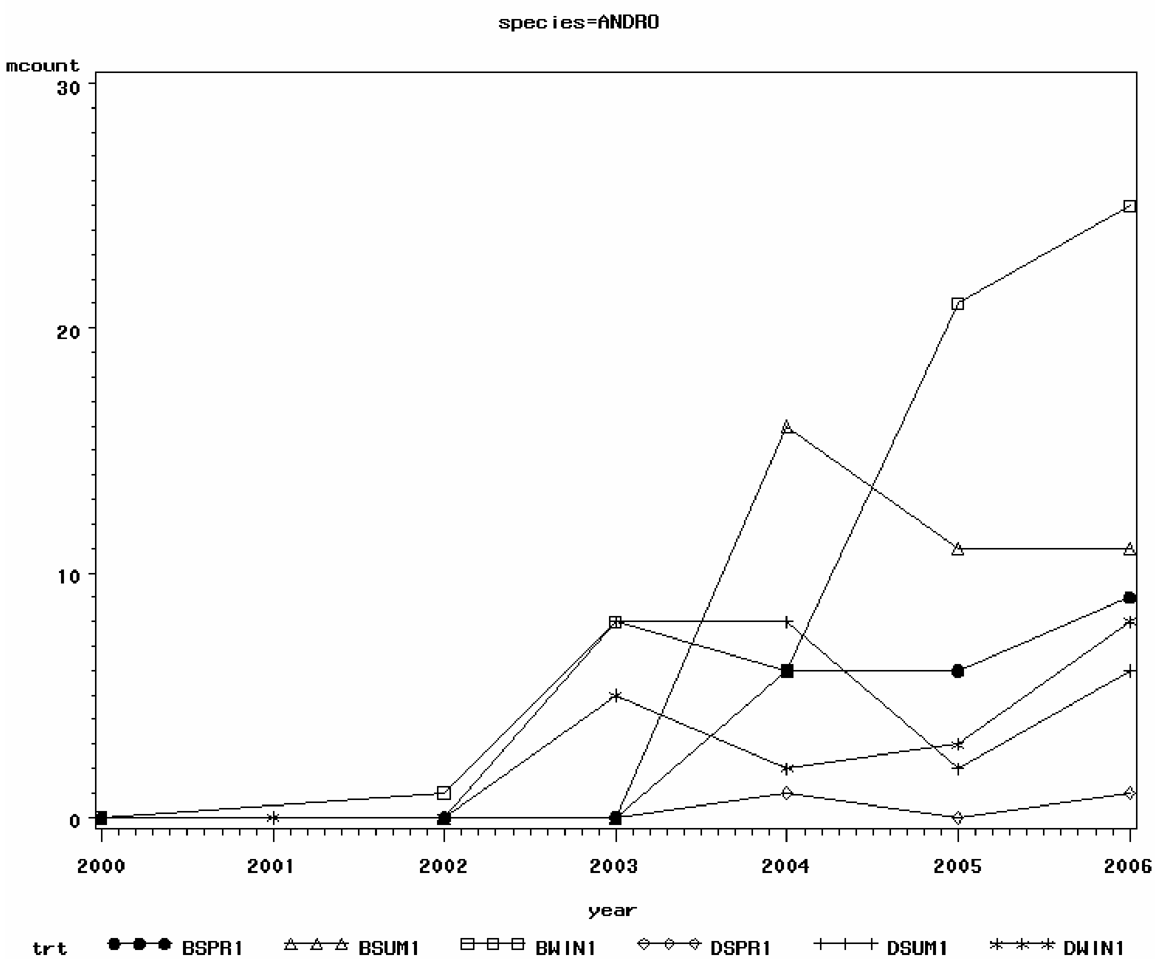

Figure 2.11: Mean broomsedge (*Andropogon virginicus*) occurrences in biannual disturbance treatments over time.

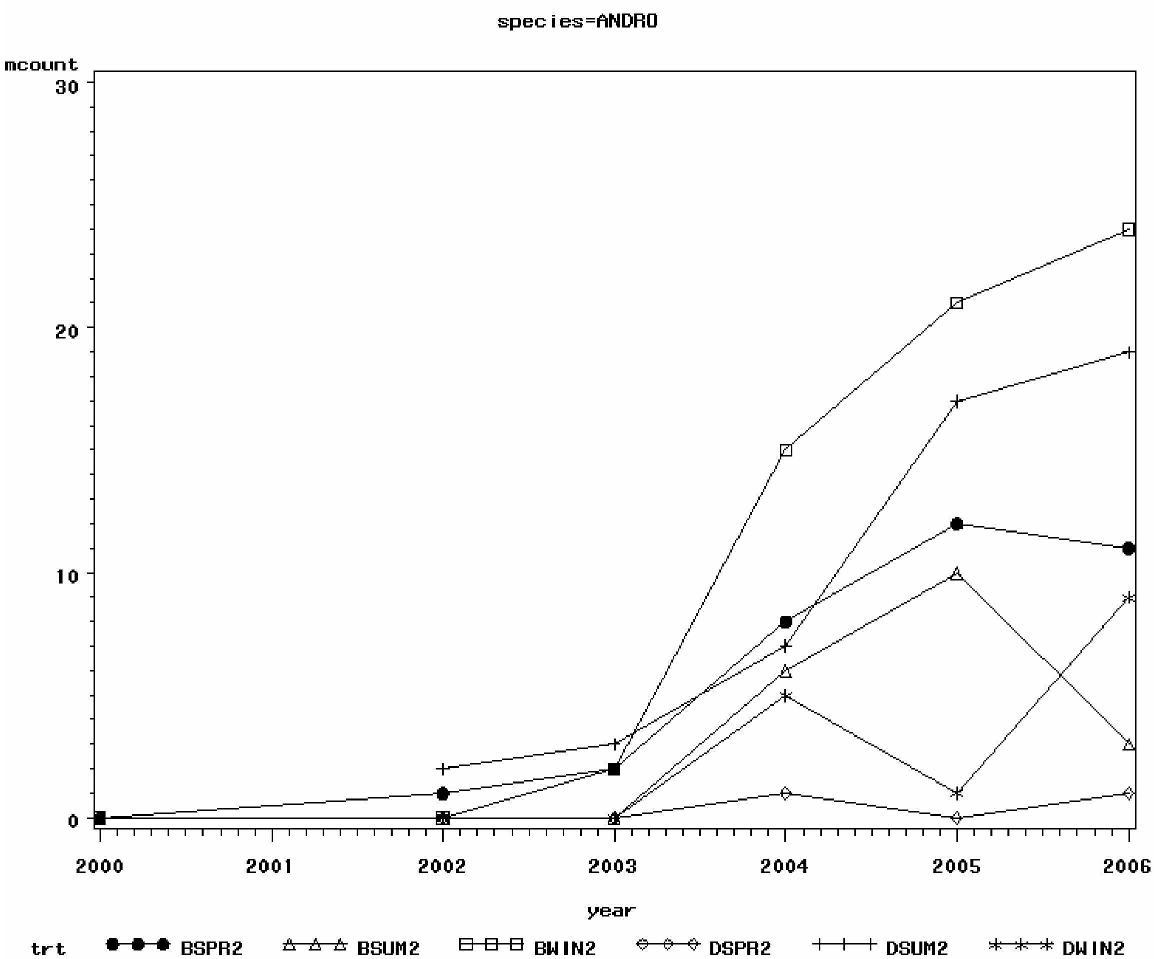

Figure 2.12: Mean broomsedge (*Andropogon virginicus*) occurrences in triennial disturbance treatments over time.

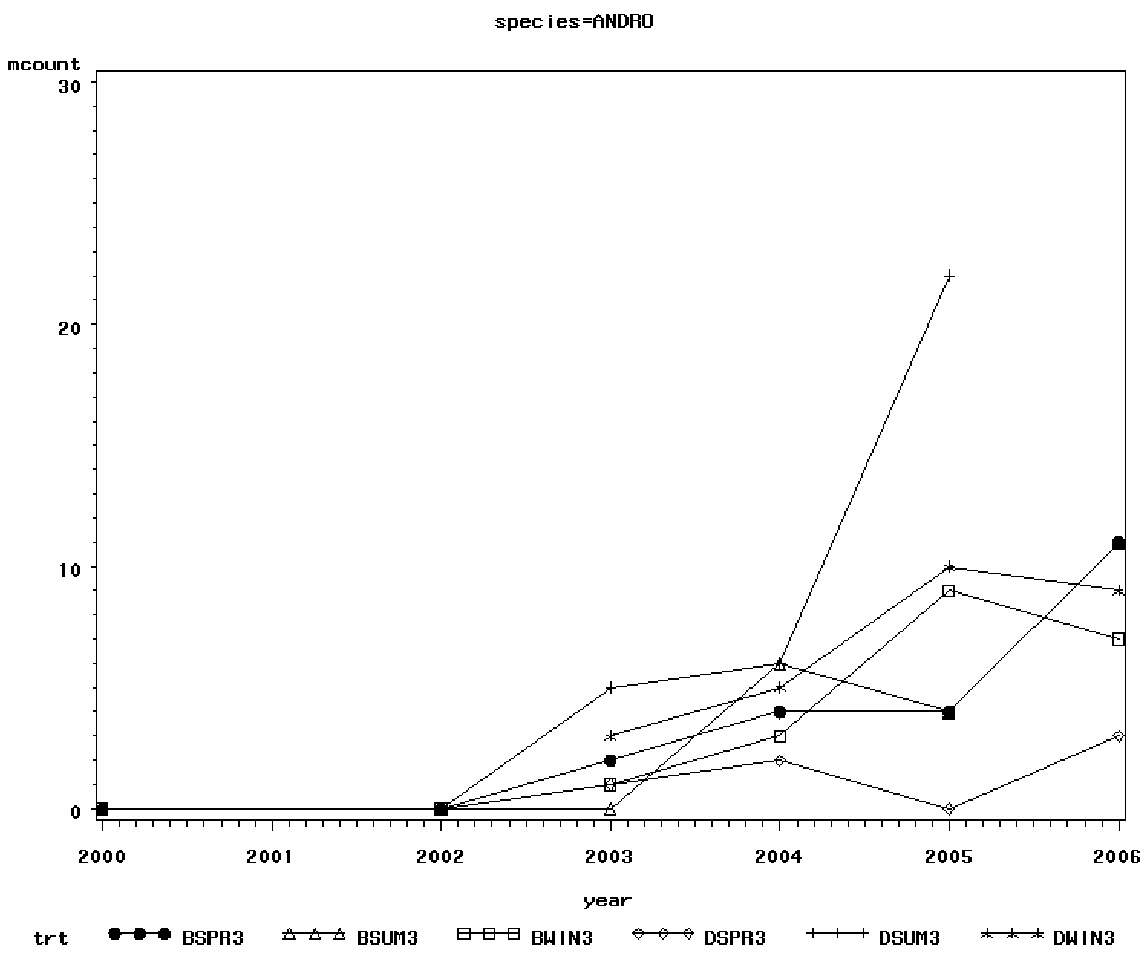

Figure 2.13: Mean rattlebox (*Crotalaria spectabilis*) occurrences in annual disturbance treatments over time.

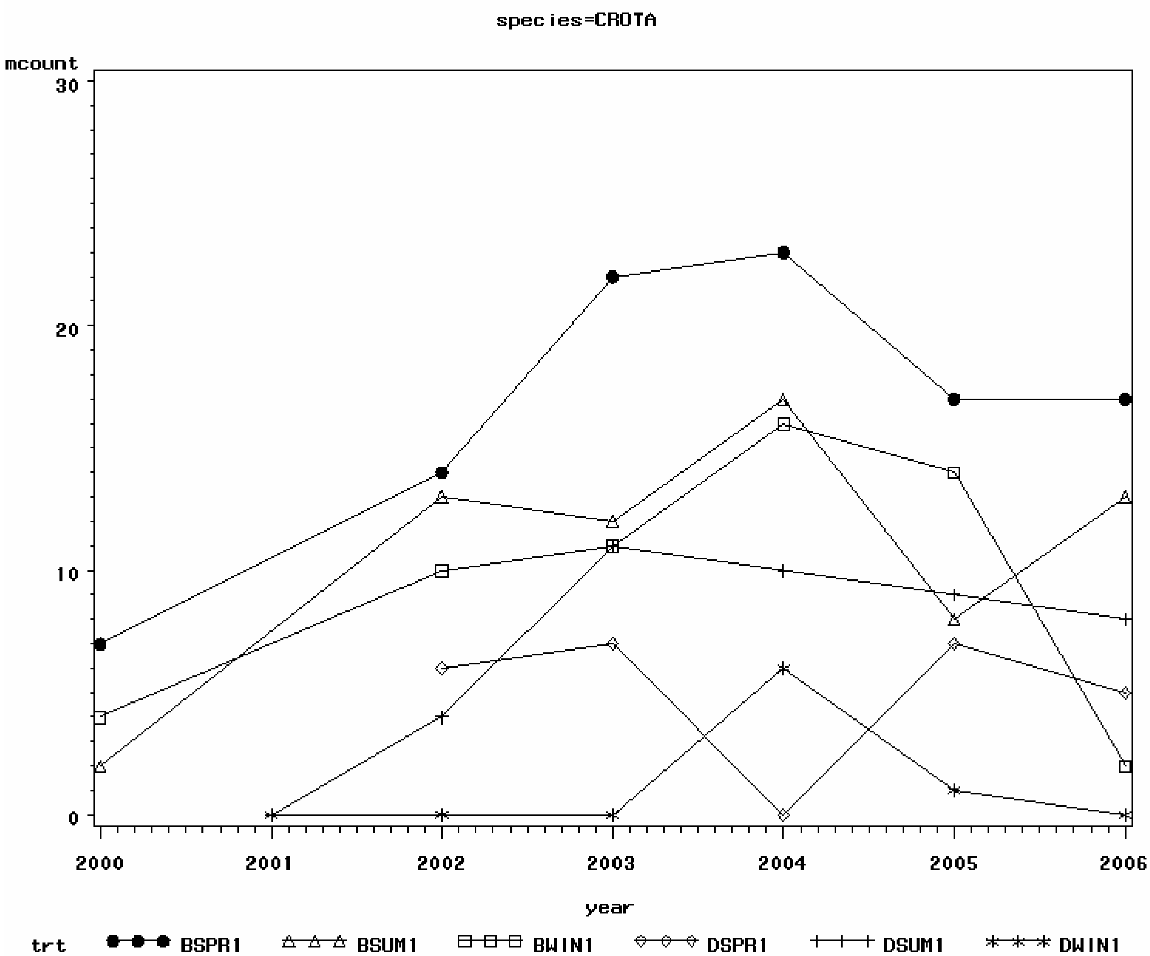

Figure 2.14: Mean rattlebox (*Crotalaria spectabilis*) occurrences in biannual disturbance treatments over time.

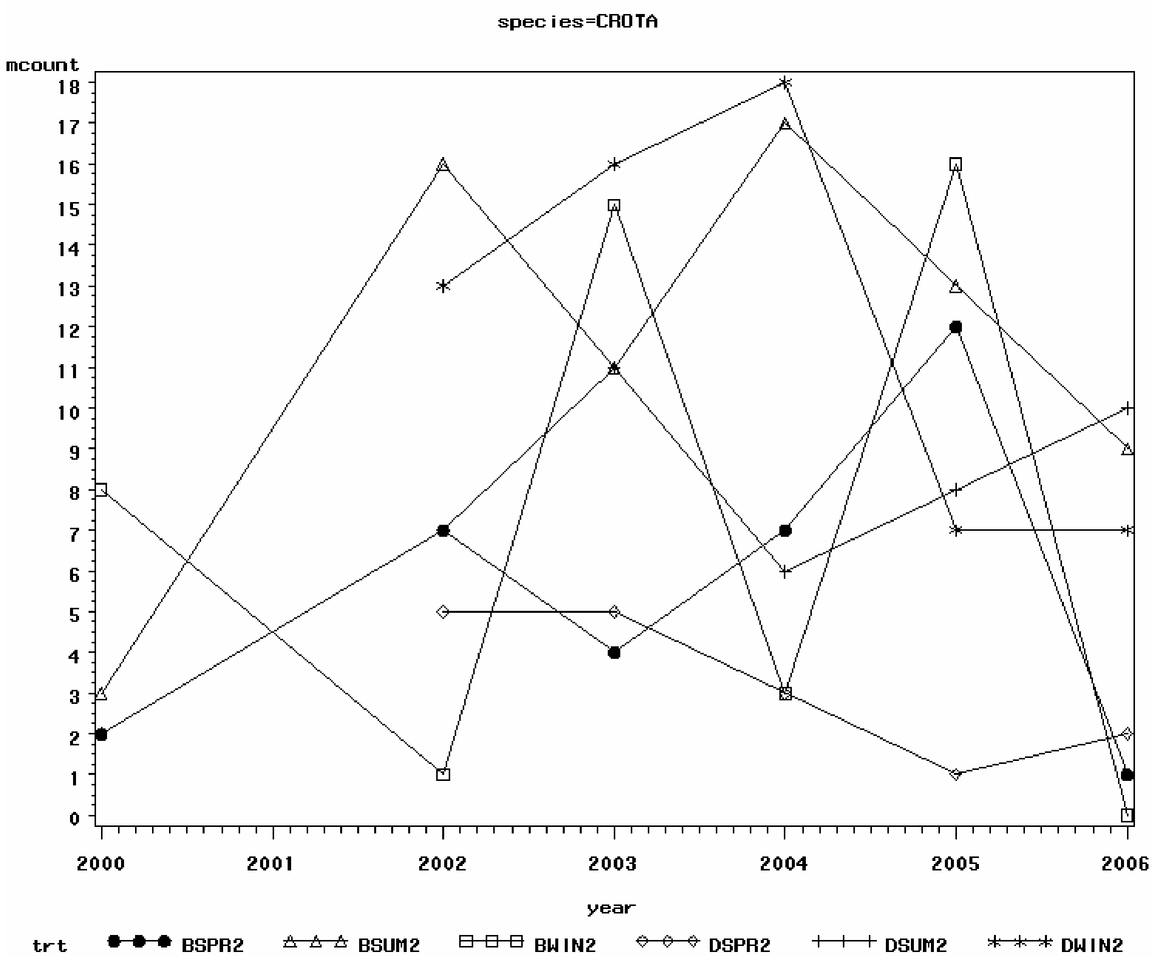

Figure 2.15: Mean rattlebox (*Crotalaria spectabilis*) occurrences in triennial disturbance treatments over time.

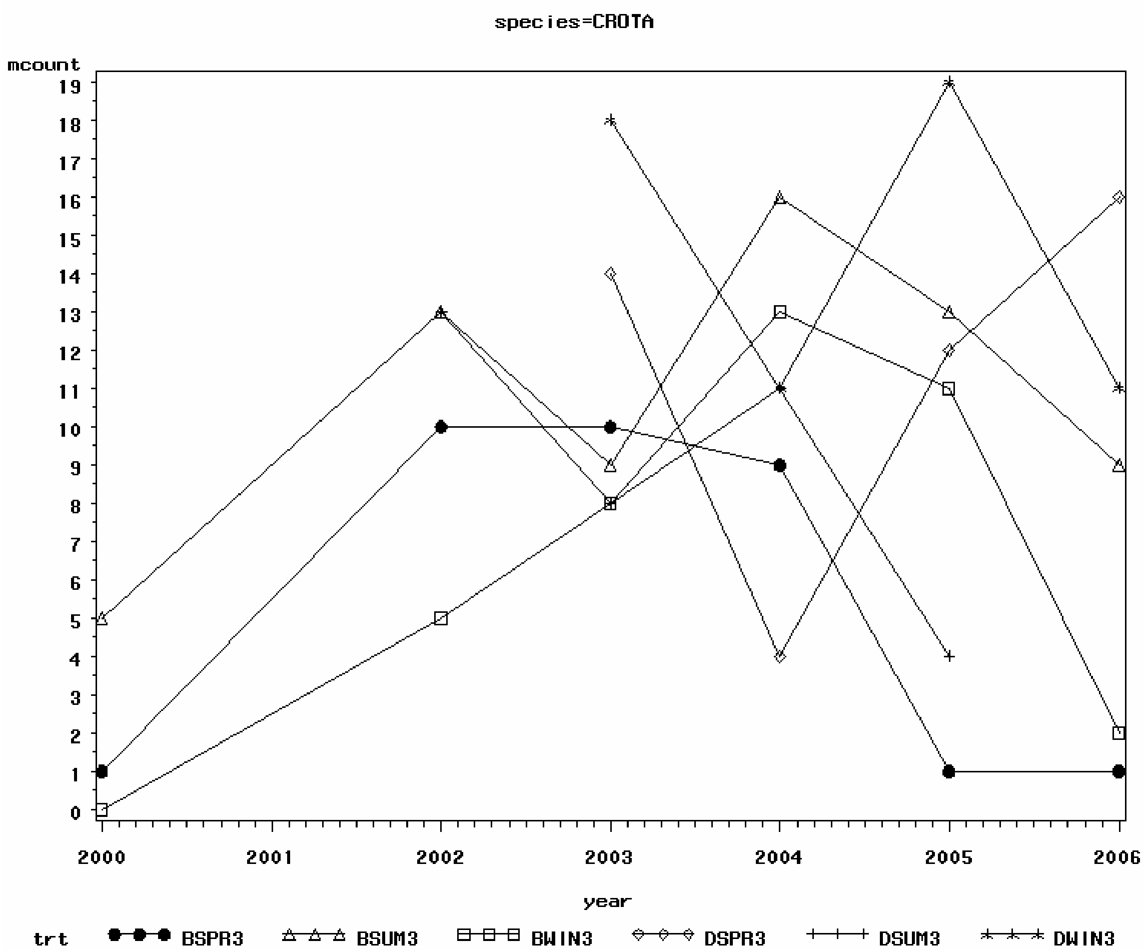

Figure 2.16: Mean crabgrass (*Digitaria* spp.) occurrences in annual disturbance treatments over time.

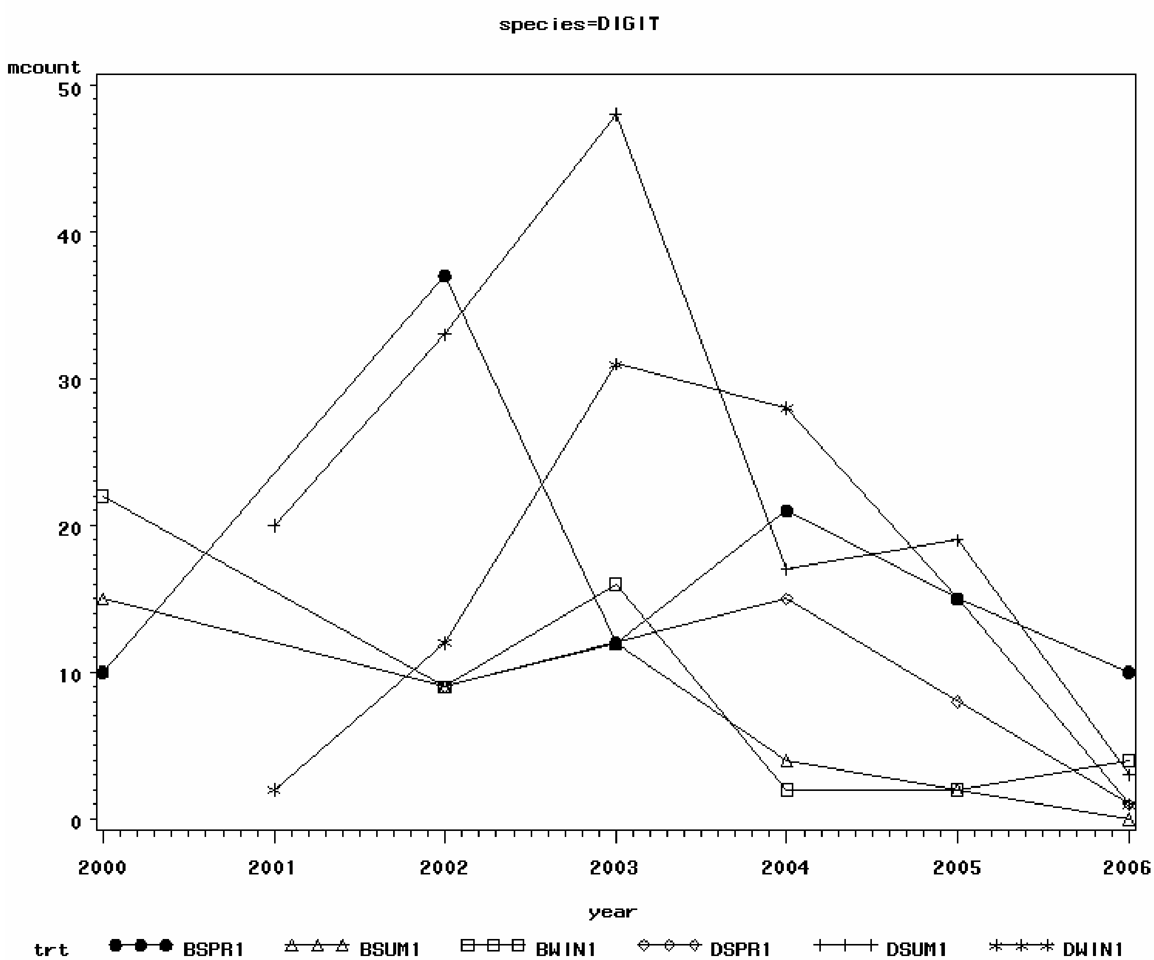

Figure 2.17: Mean crabgrass (*Digitaria* spp.) occurrences in biannual disturbance treatments over time.

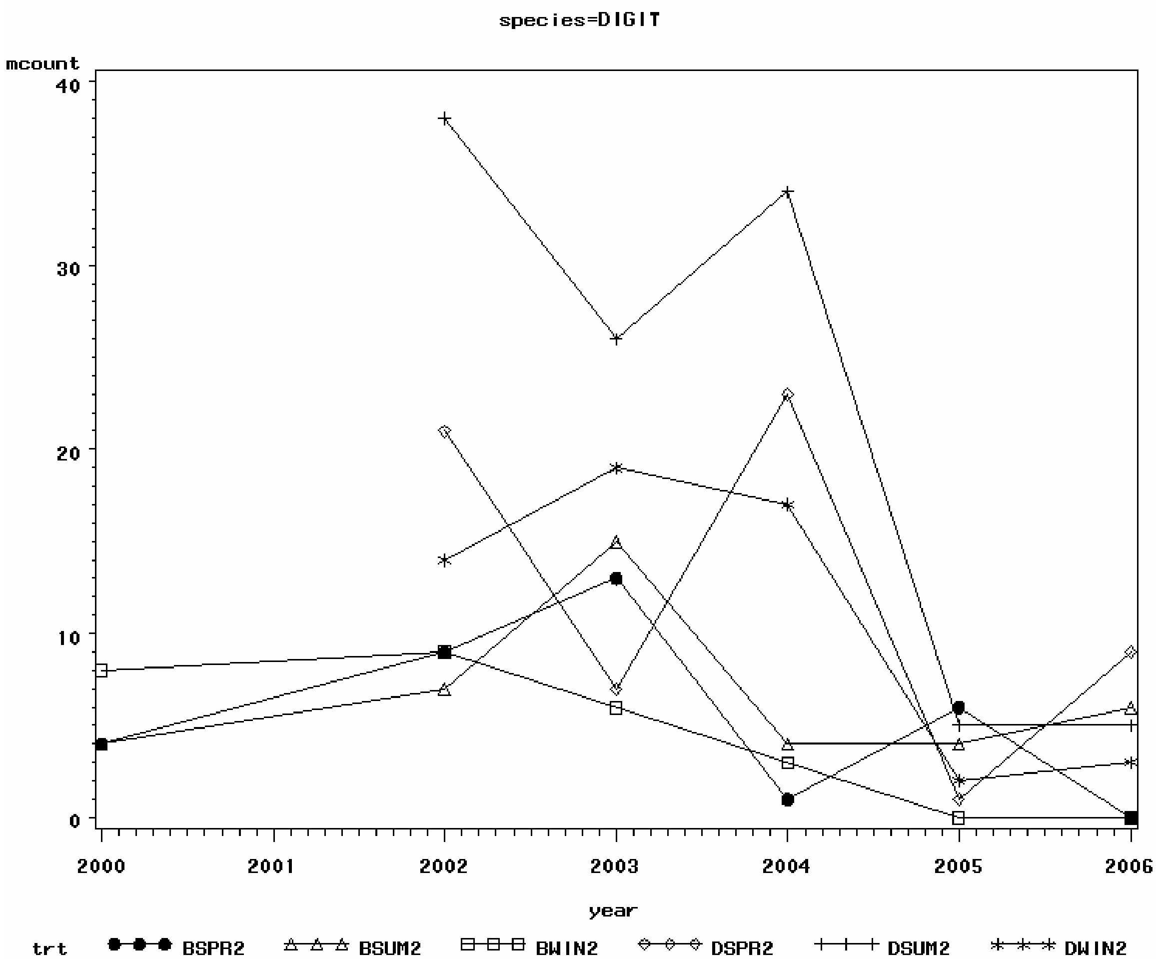

Figure 2.18: Mean crabgrass (*Digitaria* spp.) occurrences in triennial disturbance treatments over time.

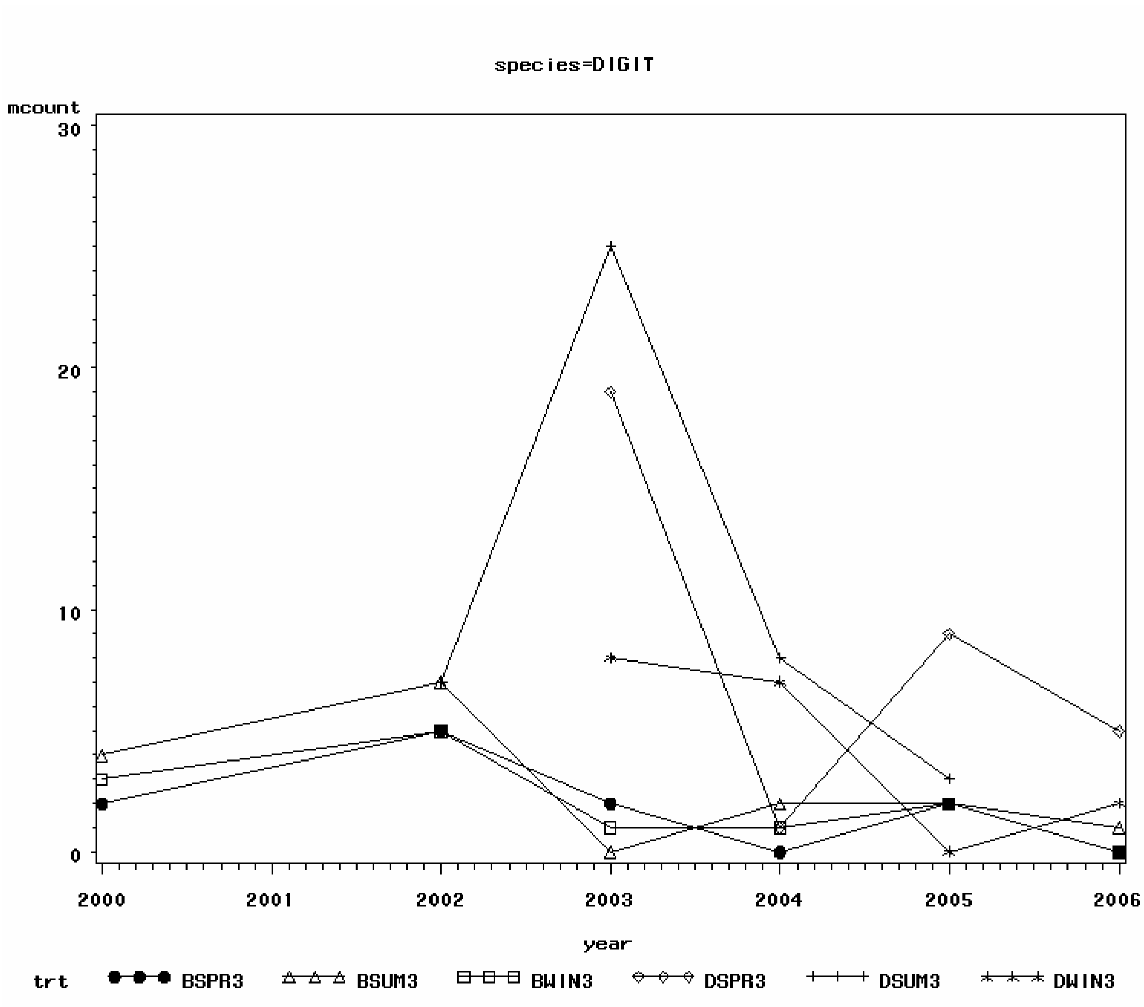

Figure 2.19: Mean panicgrass (*Panicum* spp.) occurrences in annual disturbance treatments over time.

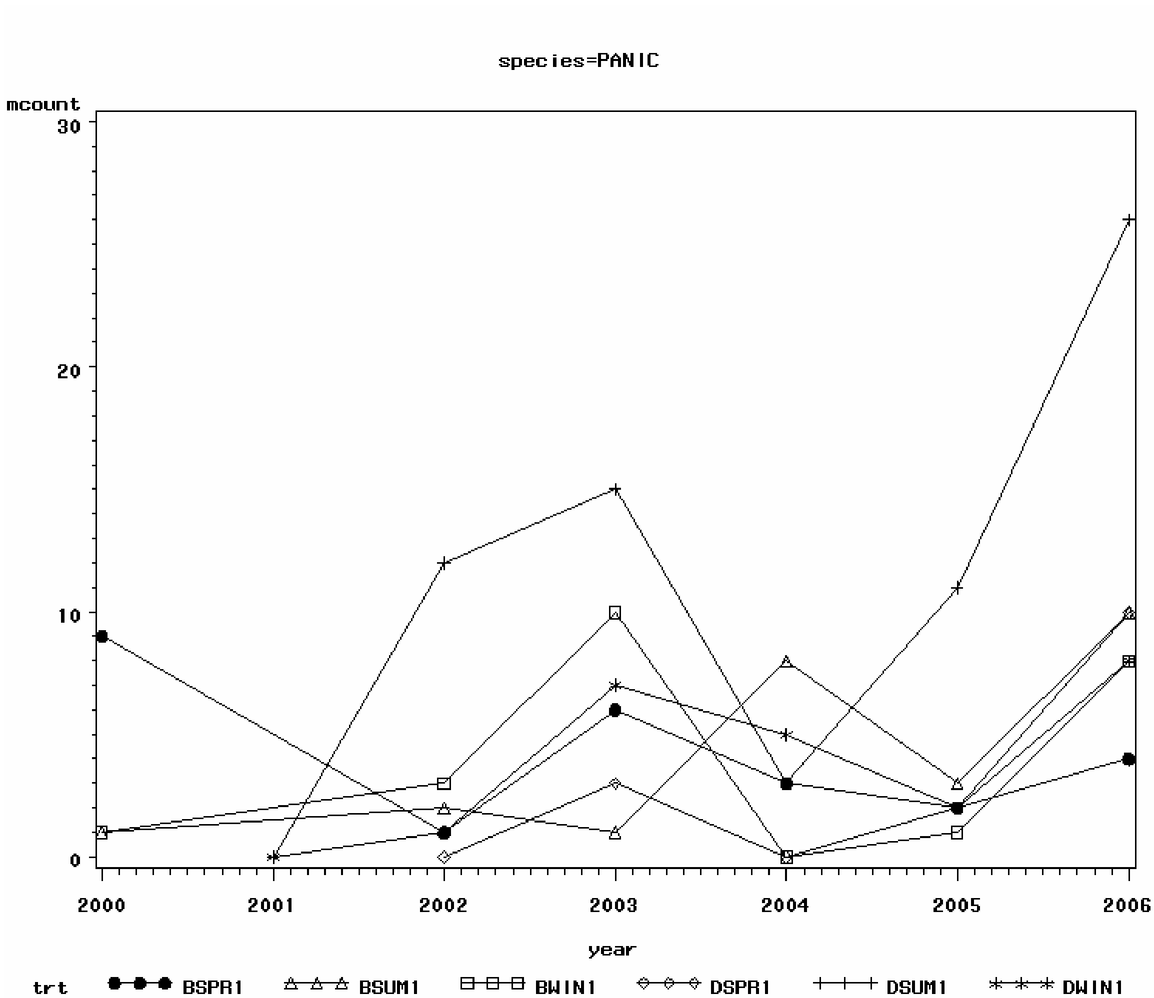

Figure 2.20: Mean panicgrass (*Panicum* spp.) occurrences in biannual disturbance treatments over time.

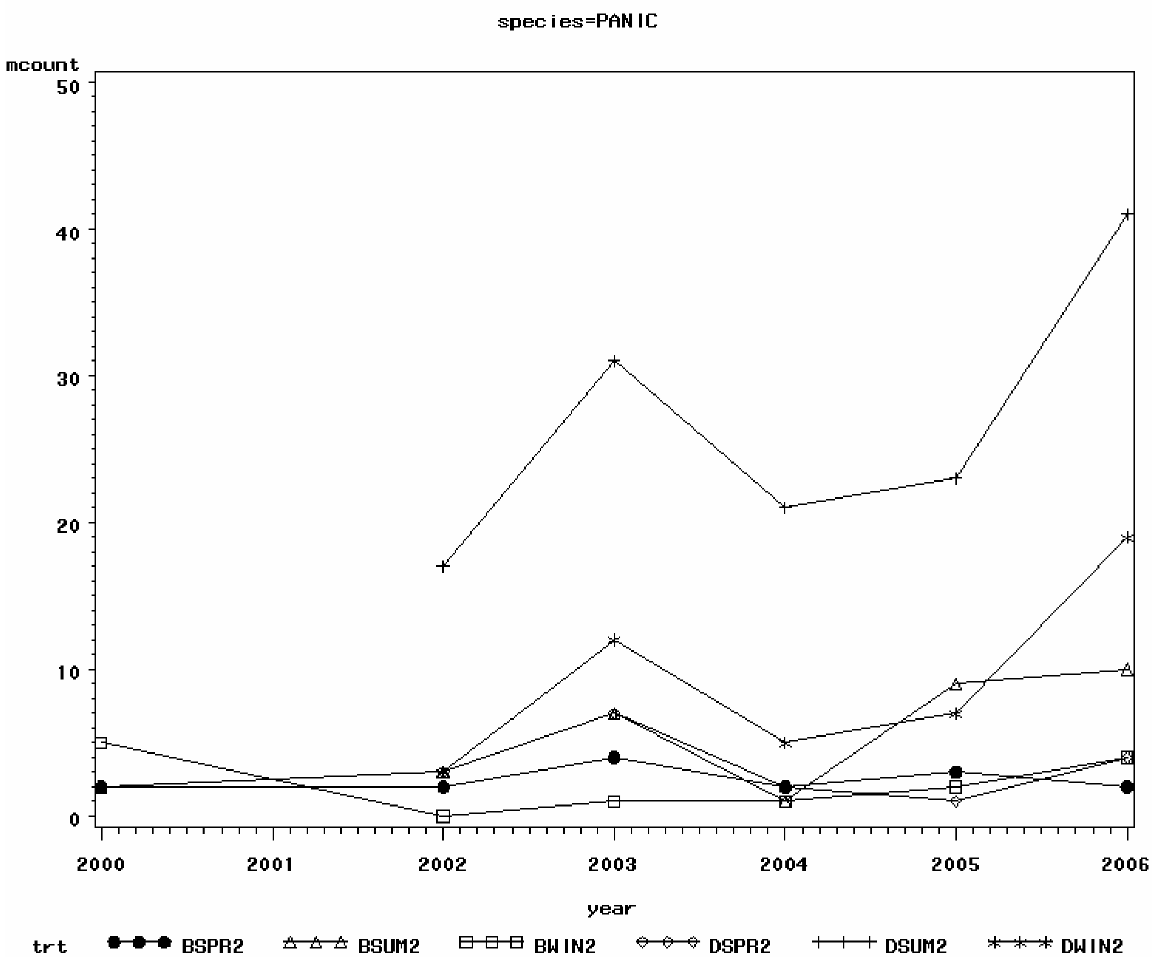

Figure 2.21: Mean panicgrass (*Panicum* spp.) occurrences in triennial disturbance treatments over time.

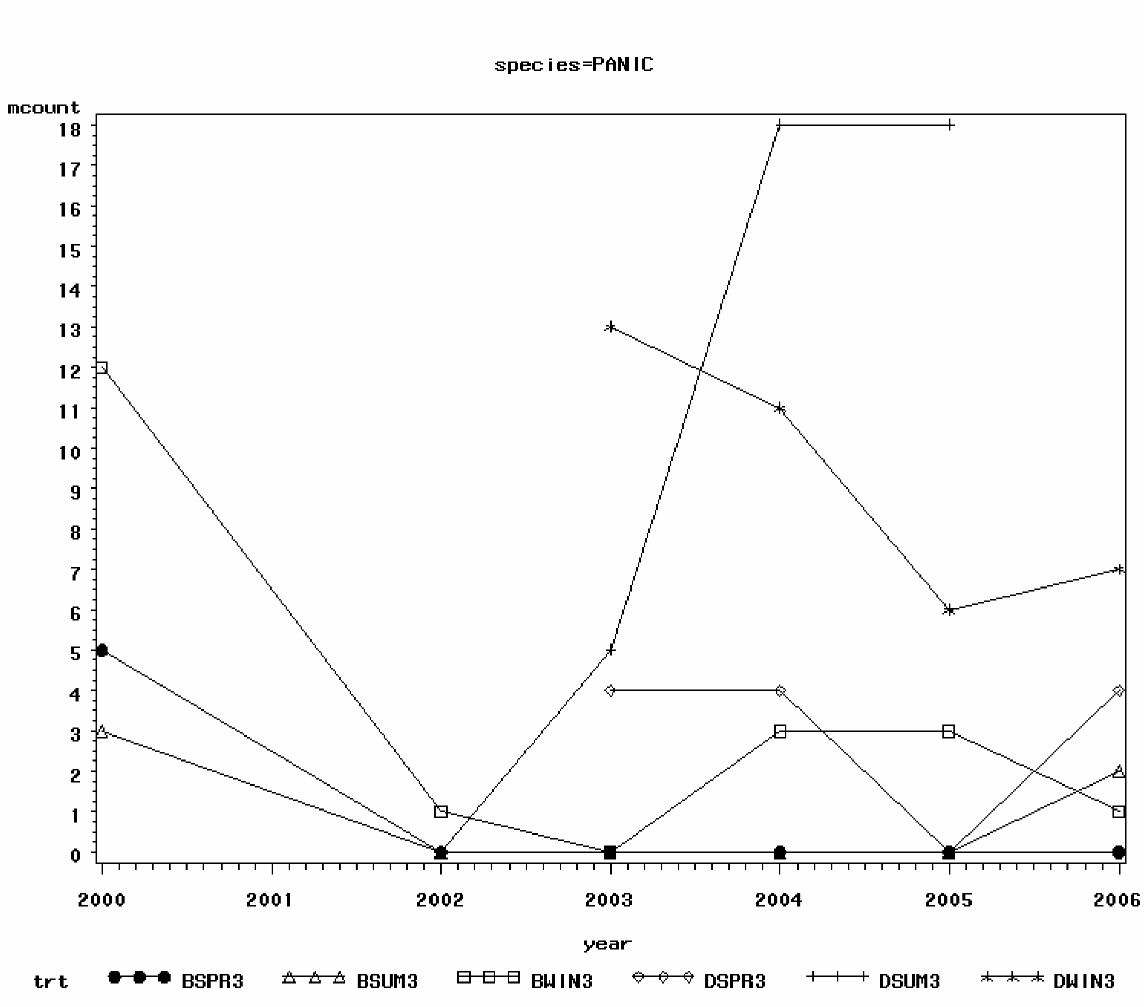

Figure 2.22: Mean ragweed (*Ambrosia artemisiifolia*) occurrences in annual disturbance treatments over time.

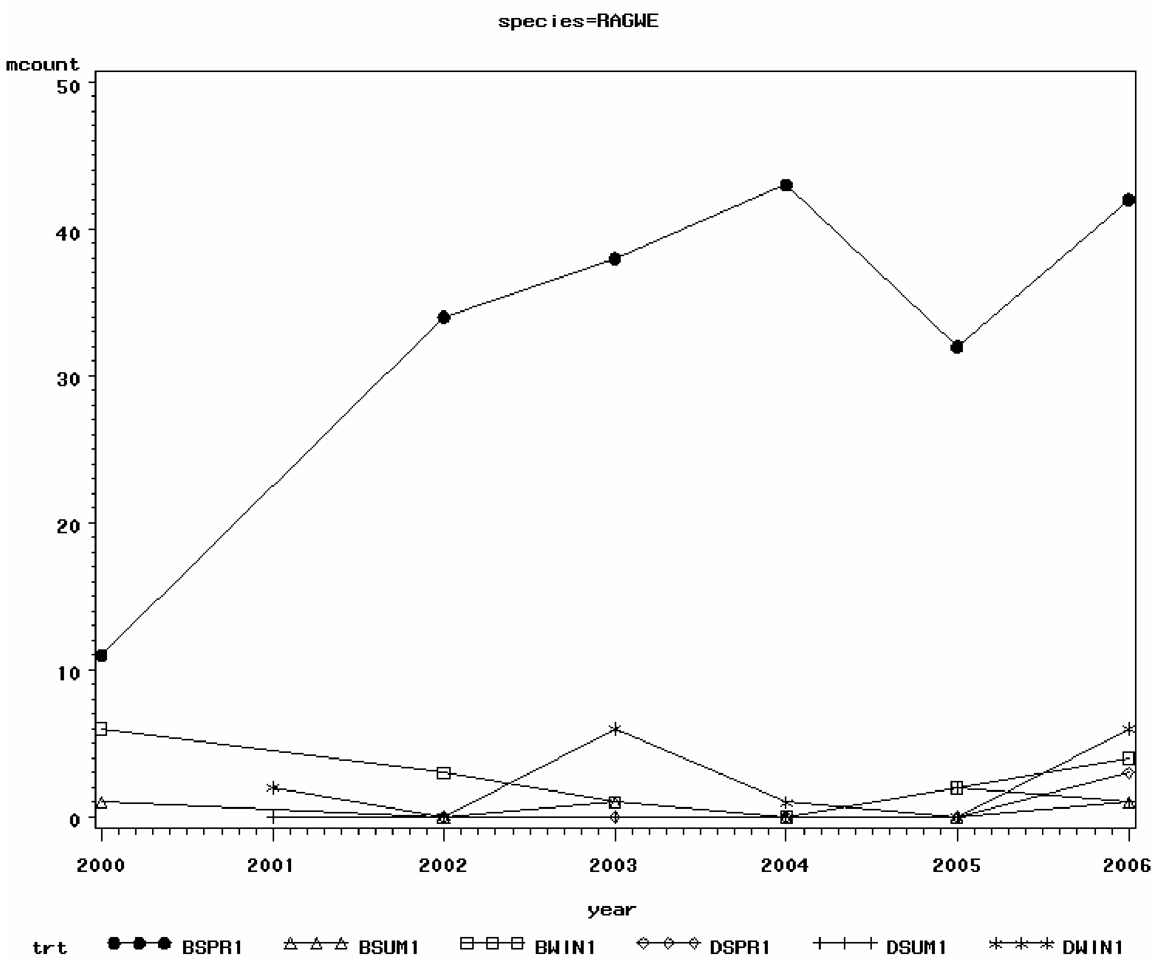

Figure 2.23: Mean ragweed (*Ambrosia artemisiifolia*) occurrences in biannual disturbance treatments over time.

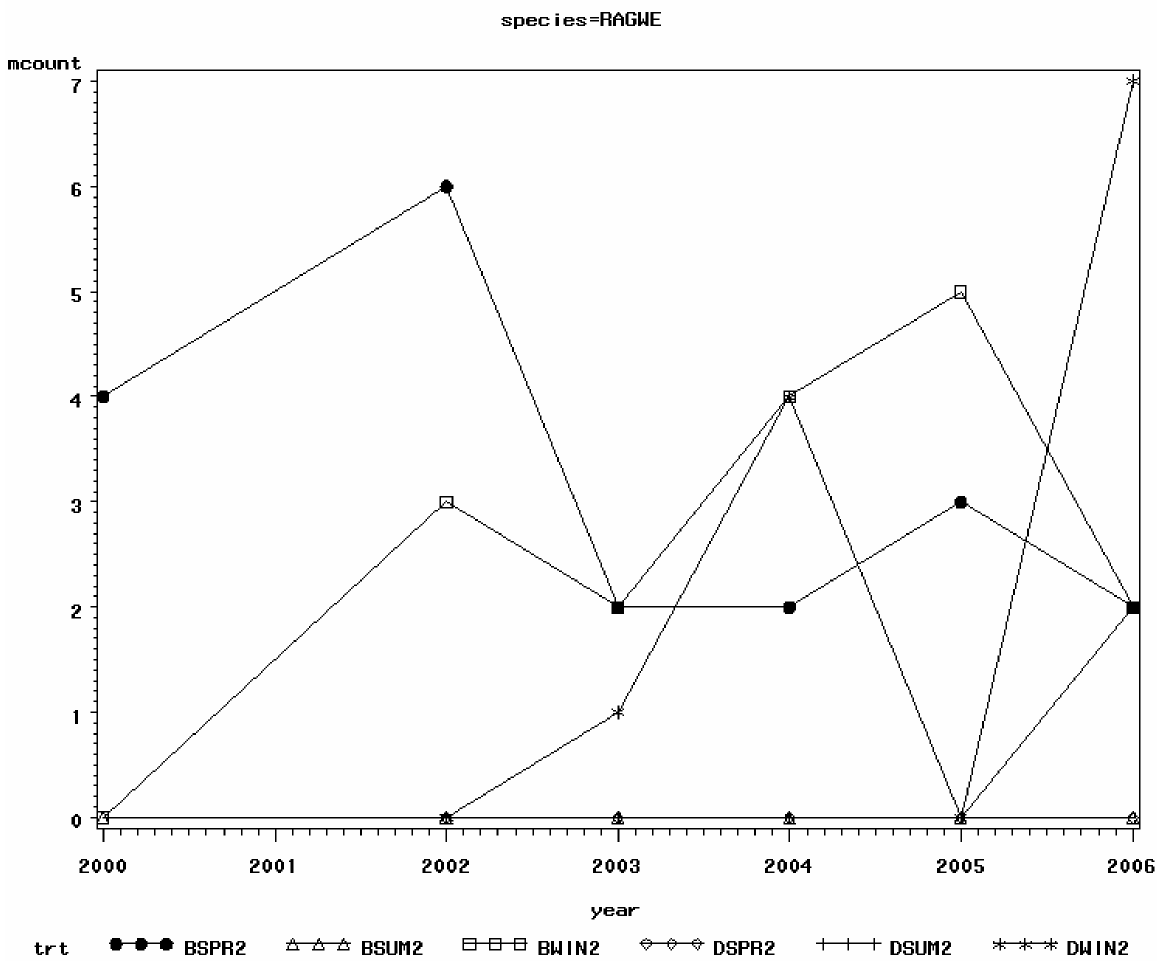

Figure 2.24: Mean ragweed (*Ambrosia artemisiifolia*) occurrences in triennial disturbance treatments over time.

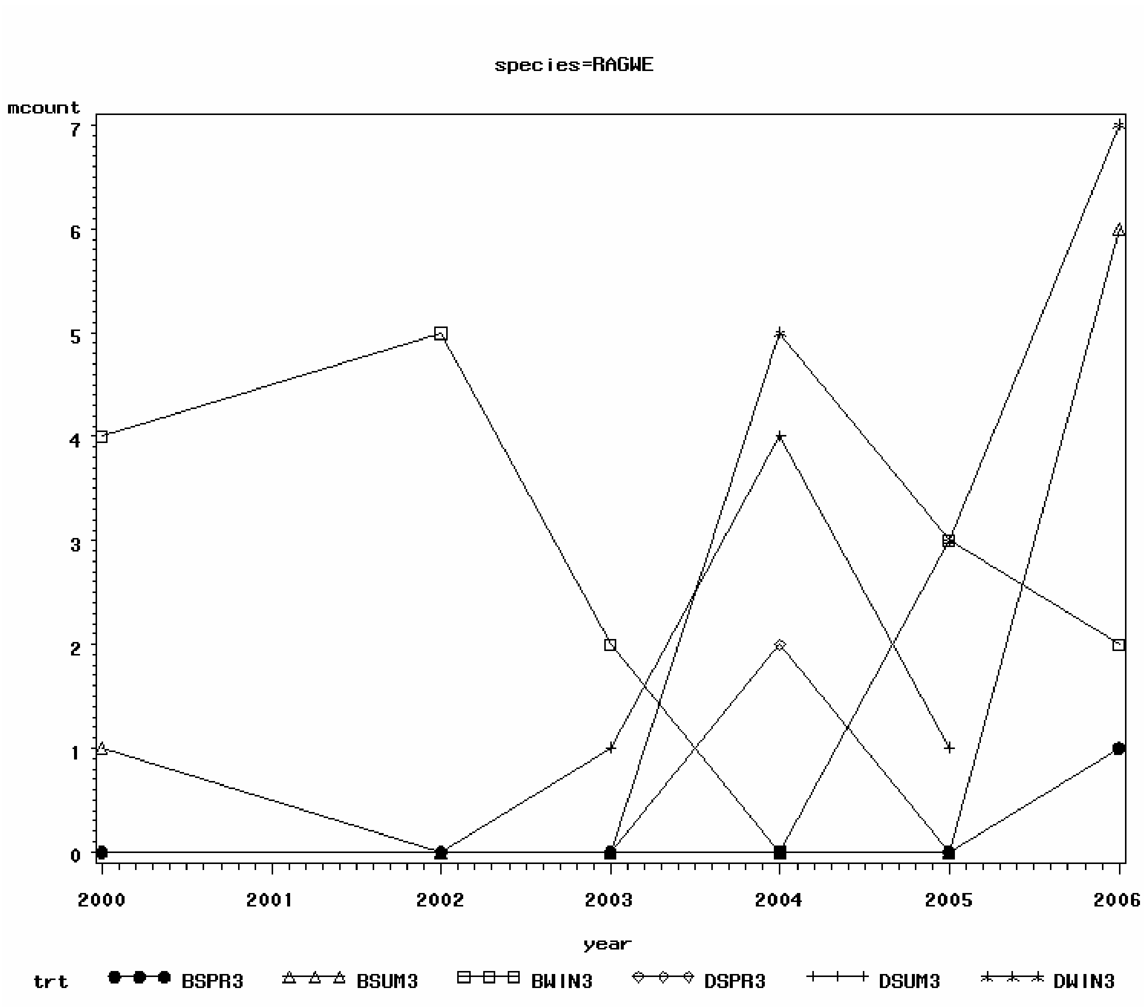

Figure 2.25: Mean dewberry (*Rubus* spp.) occurrences in annual disturbance treatments over time.

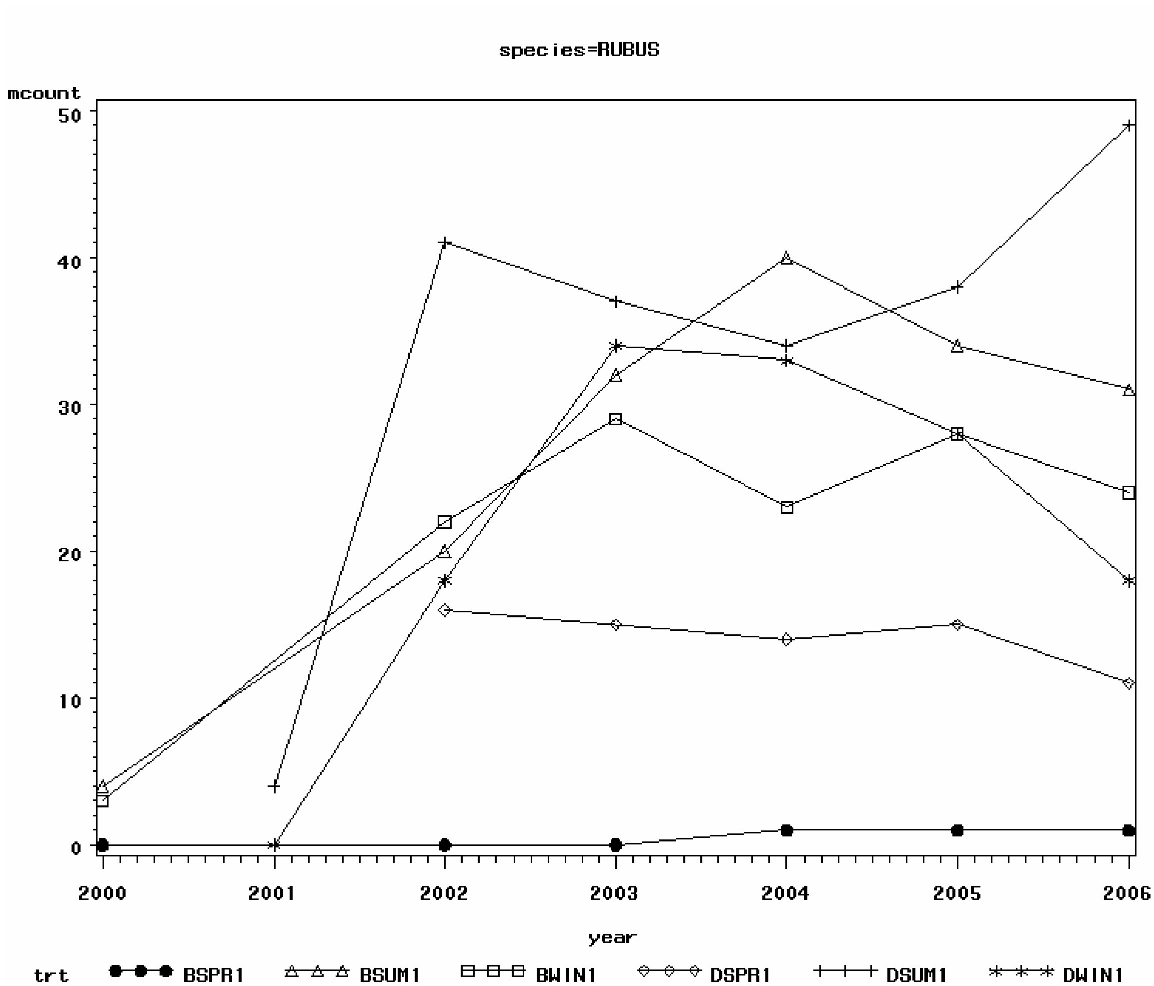

Figure 2.26: Mean dewberry (*Rubus* spp.) occurrences in biannual disturbance treatments over time.

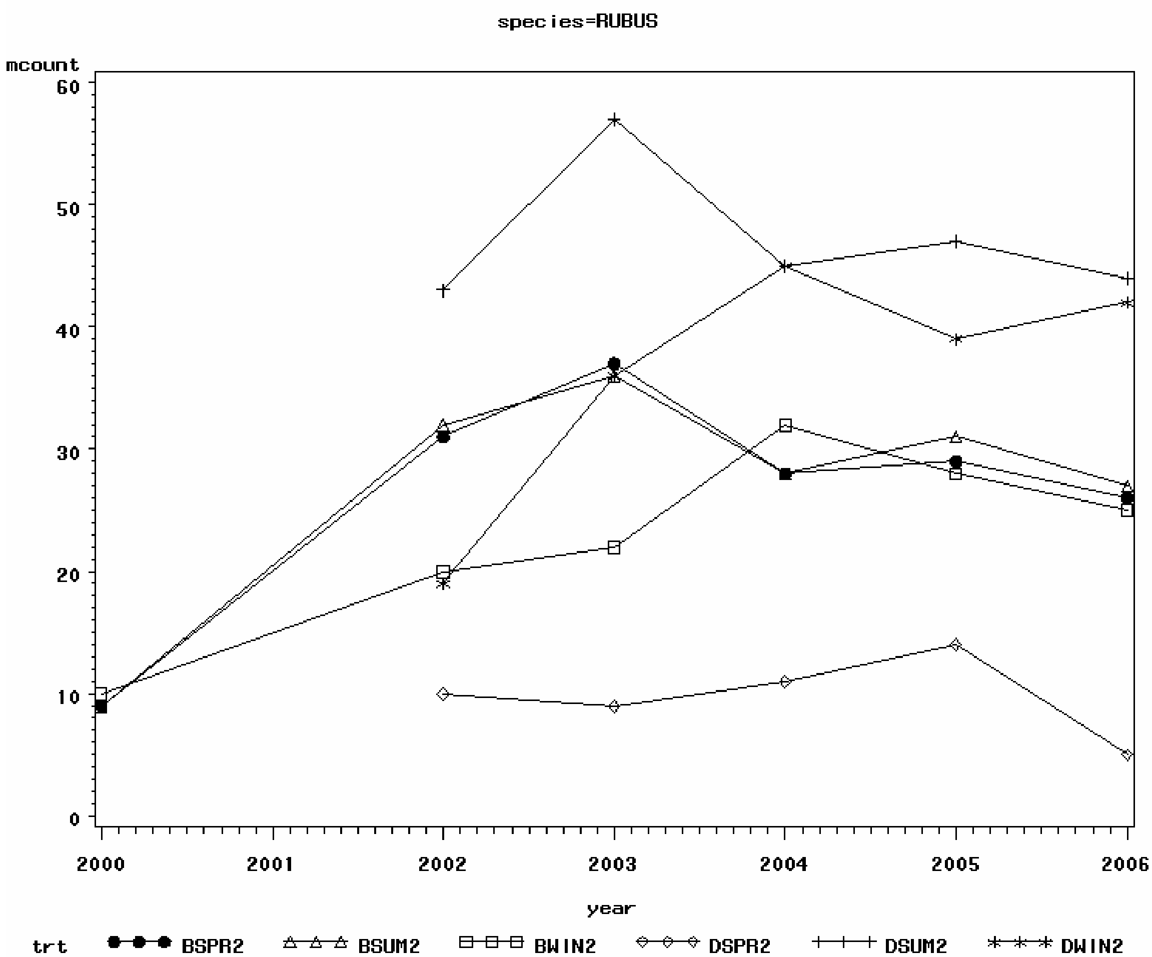

Figure 2.27: Mean dewberry (*Rubus* spp.) occurrences in triennial disturbance treatments over time.

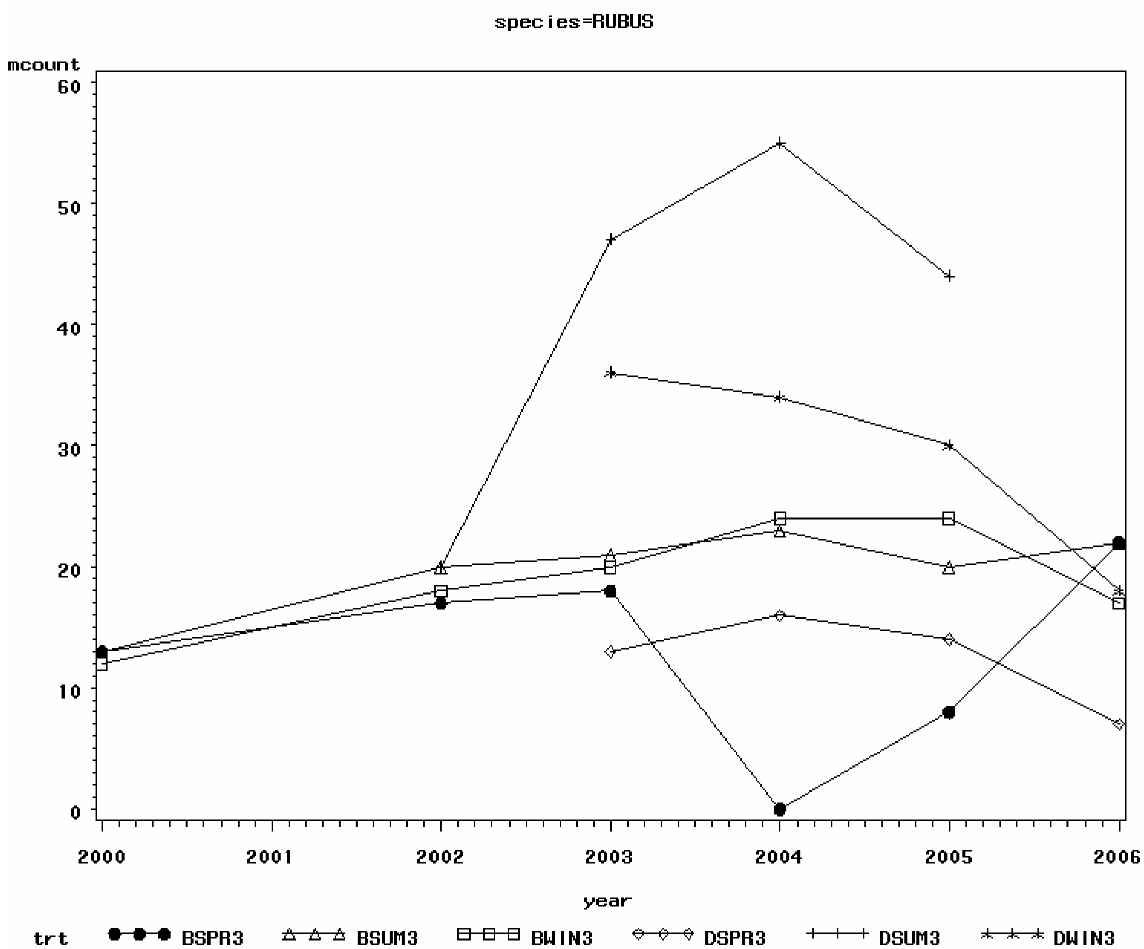

Table 2.1: Ground cover percentages for disturbance treatments. Designated treatment, mean percentage of grass coverage, mean percentage of forb coverage, mean percentage of woody stem coverage, mean percentage of bare soil, and mean percentage of debris coverage.

Treatment	%Grass	%Forb	%Woody	%Soil	%Debris
Burn Spring 1	44	53	5	11	11
Burn Spring 2	42	57	6	18	12
Burn Spring 3	40	56	6	9	10
Burn Summer 1	43	53	5	12	11
Burn Summer 2	31	64	12	11	12
Burn Summer 3	34	60	8	10	11
Burn Winter 1	45	50	6	13	11
Burn Winter 2	48	53	4	9	9
Burn Winter 3	40	60	5	8	8
Disk Spring 1	40	50	0	7	2
Disk Spring 2	35	54	0	6	4
Disk Spring 3	26	66	0	7	3
Disk Summer 1	36	49	0	11	4
Disk Summer 2	39	54	0	3	5
Disk Summer 3	31	55	3	4	7
Disk Winter 1	33	52	0	11	4
Disk Winter 2	17	71	0	5	7
Disk Winter 3	16	69	1	6	6

Table 2.2: Species richness for disturbance treatments.
Designated treatment, number of grass species found, number of forb species found, number of woody species found, and total number of species found within the treatment.

Treatment	Grass	Forb	Woody	Total
Burn Spring 1	12	35	1	48
Burn Spring 2	15	35	3	53
Burn Spring 3	11	34	1	46
Burn Summer 1	14	41	3	58
Burn Summer 2	9	36	5	50
Burn Summer 3	12	39	0	51
Burn Winter 1	10	36	3	49
Burn Winter 2	8	30	1	39
Burn Winter 3	9	30	3	42
Disk Spring 1	7	24	1	32
Disk Spring 2	9	25	0	34
Disk Spring 3	5	22	0	27
Disk Summer 1	14	42	0	56
Disk Summer 2	10	33	3	46
Disk Summer 3	10	31	2	43
Disk Winter 1	10	34	1	45
Disk Winter 2	9	34	2	45
Disk Winter 3	9	24	4	37

Table 2.3: List of species found in study fields.
Grass species, forb species, vine species, and tree or shrub species found in the treatment plots during the study.

Grasses	Forbes	Vines	Trees/Shrubs
+*Andropogon gerardii*	*Acalypha gracilens*	*Ampelopsis arborea*	*Acer rubra*
+*Andropogon virginicus*	*Agalinis fasciculate*	-*Ipomoea hederacea*	*Baccharis halimifolia*
+*Aristida beyrichiana*	+*Ambrosia artemisiifolia*	-*Jacquemontia tamnifolia*	*Diospyros virginiana*
+*Bouteloua curtipendula*	*Carphephorus* spp.	*Passiflora incarnata*	*Liquidambar stryaciflua*
-*Bracharia* spp.	-*Cenchrus echinatus*	-*Rubus* spp.	*Liriodendron tulipifera*
+*Carex cephalophora*	+*Chamaecrista fasciculata*	*Vitis rotundifolia*	*Myrica cerifera*
-*Cynodon dactylon*	-*Conyza canadensis*		*Nyssa sylvatica*
+*Cyperus echinatus*	-*Crotalaria spectabilis*		*Pinus palustris*
+*Dactyloctenium aegyptium*	+*Croton capitatus*		*Pinus taeda*
+*Dichanthelium* spp.	+*Desmanthus illinoensis*		*Querculs velutina*
+*Digitaria ciliaris*	+*Desmodium obtusum*		*Quercus alba*
+*Eragrostis spectabilis*	*Duchesnea indica*		*Quercus coccinea*
Heteropogon contortus	*Erigeron annus*		*Quercus falcata*
Juncus spp.	-*Eupatorium capillifolium*		*Quercus nigra*
+*Lolium perenne*	*Euthamia tenuifolia*		*Quercus pagoda*
-*Microstegium vimineum*	*Gamochaeta purpea*		*Quercus Rubra*
+*Muhlenbergia schreberi*	*Geranium carolinianum*		*Quercus stellata*
+*Panicum* spp.	*Gnaphalium obtusifolium*		*Quercus virginiana*
-*Paspalum notatum*	+*Helenium amarum*		*Sapium sebiferum*
-*Paspalum urvillei*	-*Heterothera subaxillaris*		
Rhynchospora cephalantha	*Hypericum gentianoides*		
+*Schizachyrium scoparium*	-*Lespedeza sericea*		
+*Setaria glauca*	+*Lespedeza thunburgii*		
-*Sorghum halepense*	*Ludwigia alternifolia*		
	+*Melochia corchorifolia*		
	-*Mollugo verticillata*		
	Oxalis stricta		
	-*Phyllanthus amarus*		
	Plantago spp.		
	+*Polygonum hydropiper*		
	Polypremum procumbens		
	+*Rhexia* spp.		
	Rhynchosia reniformis		
	-*Senna obtusifolia*		
	-*Sesbania herbacea*		
	Solidago spp.		
	Verbena brasiliensis		
	Viola affinis		

+ = desirable, - = not desirable, blank = provides cover, not especially important but not an obnoxious problem

Table 2.4: Woody stem density for disturbance. treatments. Designated treatment and mean number of stems in an eight meter radius.

Treatment	# Stems
Burn Spring 1	5.1
Burn Spring 2	4.6
Burn Spring 3	5.5
Burn Summer 1	5.2
Burn Summer 2	5.7
Burn Summer 3	8.0
Burn Winter 1	4.4
Burn Winter 2	3.6
Burn Winter 3	4.5
Disk Spring 1	2.6
Disk Spring 2	3.3
Disk Spring 3	3.3
Disk Summer 1	4.8
Disk Summer 2	3.7
Disk Summer 3	5.5
Disk Winter 1	3.0
Disk Winter 2	5.0
Disk Winter 3	3.3

CHAPTER 3

SONGBIRD RESPONSE TO FIELD MANAGEMENT PRACTICES

Abstract

Losses of early-successional habitat throughout the United States have lead to declines in populations of many shrub-scrub bird species (Klaus et al. 2005, Hogan 1993, Hunt 1998, Burger 2004, Brennan 1991, Langer 1989, MacGowen 2001). In response to declines of early-successional habitat and associated songbirds the USDA Natural Resources Conservation Service (NRCS) developed guidelines for the management of early-successional habitat. In this study, we examined nesting and wintering songbird use of fields being managed for early successional habitat. Painted bunting, indigo bunting, and blue grosbeak were the most common species found nesting on the study site. We found variation in nesting success and productivity within each species between years. Nest habitat components measured in this study indicated there were no differences between successful and unsuccessful nest sites. We detected interspecific variation in nest sites, but the three most common nesters appeared to have very similar nesting habitat requirements. Nests found during the study were most commonly located in field borders and hedgerows. Wintering songbird use of the study area was recorded during January and February of 2006. Drives were used to count birds flushed from treatment plots. The greatest numbers of wintering songbirds were found in plots that were burned in the spring or winter. Analysis of habitat availability compared to bird presence indicated that wintering songbirds selected areas without respect to

size/availability of habitat. We theorize that field location may have contributed to bird usage. Our results indicate that spring and summer prescribed burns applied on a 1-3 year frequency created habitat that was preferred by early-successional songbirds. Land managers in the lower Coastal Plain of South Carolina may obtain better results from spring burning due to the difficulty of performing a summer burn. Land managers are advised to apply disturbances on a 2 year frequency as growing conditions may reduce the quality of habitat with disturbances occurring less frequently.

Introduction

Early-successional songbirds in the southeastern United States have experienced drastic population declines over the past half century (Price et al. 1995, Springborn et al. 2005). Species such as the painted bunting (*Passerina ciris*), indigo bunting (*Passerina cyanea*), and blue grosbeak (*Guiraca caerulea*) commonly nest in agricultural settings in the lower Coastal Plain of South Carolina. These species typically favor brushy weedy areas that are associated with abandoned fields (Ehrlich et al. 1988). The early-successional habitat favored by the above mentioned species is a temporal habitat that is in constant progression towards becoming forested. Areas like the lower Coastal Plain of South Carolina have a long growing season and relatively high annual precipitation level, which allows plant succession to progress at a rapid rate. In the absence of disturbance, areas that provided quality habitat for early-successional bird species quickly become unsuitable for these avian species (MacGowen 2001).

Field management for early-successional habitat may provide the declining populations with the habitat necessary to maintain or restore populations. Recent research has mainly focused on the influence of patch size and shape on nesting success (Weldon, A.J. 2006). Weldon's research indicated corridors between isolated habitat patches decrease the nesting success of Indigo Buntings. She also found that the corridors may actually be population sinks. Research has identified the negative impacts of corridors and edge on nesting success, but the impacts field management practices have on nesting success is still unknown.

Identifying the role of field management practices in songbird populations may provide information useful for the restoration of songbird species, and aid in the development of much needed best management practices for sustaining early-successional habitats. In this study we looked at nest site selection and nesting success of songbirds in fields that were managed for early-successional habitat, field borders, hedgerows, and native warm-season grasses. We also evaluated the use of the fields by songbirds that were wintering in the area.

Study Area

This study was conducted at Nemours Plantation, which is operated by Nemours Wildlife Foundation (NWF). NWF was established in 1995 by Eugene DuPont III and family. NWF is a private 501(c)(3) operating foundation and is administered by a board of directors. Primary focuses of the foundation include: research, education, and stewardship of natural resources.

Nemours Plantation is a 4,000 ha track of land located in Beaufort County, South Carolina. The plantation lies within the Ashepoo-Combahee- Edisto (ACE) River Basin, which is located in the lower Coastal Plain, and has been designated as one of the last great places on earth by The Nature Conservancy. The plantation contains a diverse assemblage of habitats including remnant rice fields, fresh and brackish marshes, pine savannahs, upland pine and hardwood forests, bottomland hardwood forests, cypress/tupelo swamps, maritime forests, and abandoned agriculture fields.

The study area was approximately 400 ha, and consisted of 14 fields and their associated woodlands. Field size ranged from approximately 0.4 ha to 22.7 ha. Average field size was 7.5 ha. Prior to the abandonment of agriculture practices, the fields had been used for row cropping (corn/soybean) and pasture for dairy cattle.

This study was conducted in 2005 and 2006, during which time the study area was being managed to provide early-successional habitat. An ongoing study (2000-2006) of vegetation response to disturbance was under investigation in the study area during the same period as this study. Fields in the study were being managed with a combination of burn and disk treatments that were applied at various seasons and frequencies. Along with early-successional habitat management, fields were managed to provide field borders, Thunberg lespedeza (*Lespedeza thunbergii*) hedgerows, and native warm-season grasses.

Methods

Nest Searching

Nest site selection and nesting success were studied across a complex of 14 fields and their associated woodlands. Nests were found using a variety of searching techniques. Techniques included sticking, stalking, and rope dragging. The sticking technique was conducted using a bamboo pole approximately 3.5 m long. The pole was used to prod shrubs and saplings, and it was waved in a fan pattern across the top of vegetation growing in the fields to flush nesting birds.

For the stalking technique, birds were observed with binoculars carrying food or nesting material until landing spots were known. Landing spots were consequently searched for nests. The rope dragging technique required three people to conduct. A 30m rope was stretched between two people (draggers). Draggers walked through fields and allowed the rope to drag the ground behind them. The third person followed behind the rope and watched for birds to flush. When birds were flushed, a thorough search was conducted in the area.

Nests were marked with a GPS unit. A flagged pole was placed 8 m north of each nests. Nests were monitored every 3-5 days. We attempted to monitor nests every three days, but flooded conditions prohibited monitoring on several occasions. Monitoring began three days after a nest was found and ended when eggs or chicks were gone from the nests. In the event we found a nest with no eggs, we monitored the nest for three weeks to ensure we hadn't found the nest prior to laying. Nests were considered successful if at least one egg hatched. Only nest that had at least one egg laid in them were used in the calculation of nesting success. Productivity was defined as the number of chicks fledging the nest.

Nest Site Vegetation Sampling

Sampling was conducted within 1 week after chicks fledged or the nest failed. Vegetation measurements taken were vegetation height, ground cover classification, herbaceous species composition, and woody stem density. Vegetation height was measured with a Robel pole (Robel et al. 1970) in four directions using the nest as the center point. Ground cover classification was recorded using a Daubenmire frame (Higgins et al. 1996). The frame was randomly dropped twice in close proximity of each nest site. Percentage of grass, forbs, woody plant species, soil, and debris were recorded each time the frame was dropped. Species composition was recorded in the frames immediately following the recording of ground cover. Species in the frame were documented by scientific name and the percentage of the frame that they occupied. Woody stem density was recorded at each nest site. The nest was considered the center point and all stems within an 8 m radius of the tree were recorded.

The vegetation variables recorded around nest sites were also recorded at random sites throughout the study area. Transects with random starting points were walked in multiple locations within each field. Plots were established approximately 25 m apart along the transect. Transects were also walked in field borders, hedgerows, and native warm-season grass plots.

Winter Songbird Field Use

Winter songbird use of early-successional habitat and native warm-season grass plots was studied during the winter of 2006. Plots established in the vegetation study were sampled in January and February for songbird use. Drives were conducted in plots using three people (drivers). Drivers were spaced approximately equal distances from each other. The distance between drivers varied from plot to plot due to the variation of plot sizes. Drivers were spaced in a way that best covered the width of the plot. Drivers walked through the plots at an equal pace and maintained a straight line between the three drivers. Flushed birds were called out and recorded by the closest driver. Flushed birds were called out to prevent drivers from counting the same bird. Each treatment plot was sampled to provide at least three replications for each treatment. Fourteen native warm season grass plots were sampled on two separate occasions to provide 28 samples from grass plots.

Analysis

Nest Site Vegetation Data

Vegetation data collected around nest sites was analyzed using Statistical Analysis System (SAS) (SAS Institute, Inc. © 2003). Vegetation height, ground cover, species composition, and woody stem density were analyzed. The means procedure was used to obtain means for all measured vegetation variables for each species. Vegetation variables were also analyzed with ANOVAs in order to determine if there were differences between the nest sites of individual bird species. ANOVAs were also used to determine if there were differences in available habitat compared to sites selected for nesting. We hypothesized that nest sites would be similar among individual species and that nest sites would be selected based on habitat availability. Hypotheses were tested at the $\alpha=0.10$ level.

Winter Songbird Field Use

The winter time usage of fields by songbirds was analyzed using SAS. The means procedure provided the mean number of birds occurring in each treatment. ANOVAs were used to identify differences in bird abundance among treatments. ANOVAs were also used to determine if there had been selection of certain treatments by wintering songbirds. This procedure took into account the percent of the study area that each treatment comprised. We hypothesized that wintering songbird use would differ among treatments and that the use of habitats would be based upon habitat availability. Hypothesis were tested at the $\alpha=0.10$ level.

Results

Nest Success

During the 2005 nesting season, 30 nests were found. Six species of birds accounted for all 15 nests which could be identified. Species included blue grosbeak (*Guiraca caerulea*) (n=4), indigo bunting (*Passerina cyanea*) (n=1), painted bunting (*Passerina ciris*) (n=4), Northern cardinal (*Cardinalis cardinalis*) (n=1), brown thraser (*Toxostoma rufum*) (n=1), and the Eastern wild turkey (*Meleagris gallopavo*) (n=4). The remaining 15 nests were from unknown species and no eggs were found in these nests. These 30 nests were found with 71.5 man hours of effort (number of searchers x hours searched). Search effort translated to 2.38 man hours per nest found.

In 2005, only 2 nests were successful in fledging young (Table 3.1). A total of 11 individuals were fledged between the two successful nests (n=7 for the Eastern wild turkey and n=4 for the brown thrasher. The remaining 13 nests were either predated or destroyed by storms.

Nesting success was analyzed using only nests that received at least one egg during the monitoring period. Nest success was found to be very low during the 2005 nesting season. Blue grosbeak, painted bunting, and indigo bunting nest experienced total failure; nest success for all 3 species was 0%. Nest failure was due to predation (n=4 nests) and destruction of nests by severe thunderstorms (n=5). Predation of these 4 nests was likely by snakes, the predated nests remained intact and no sign egg shells were found. Wild turkey nest success was found to be 25% in 2005. Unsuccessful turkey nests were predated by raccoons (*Procyon lotor*). One of the 3 predated nests may have been abandoned prior to predation. The nest was partially flooded during one monitoring visit, and the next visit found the nest destroyed by a raccoon that was still present. The Northern cardinal nest we found was in thicket of loblolly pine that had managed to survive the summer burn treatment. This nest had 3 eggs disappear within a week of being found. We believe the nest was predated by a snake, as the nest was still intact and no sign of the egg shells were found. Productivity was very low during the 2005 season, which produced 4 brown thrasher fledglings and 7 wild turkey fledglings.

During the 2006 nesting season, 46 nests were found (Table 3.2). Six species of birds accounted for 41 nests. Species found were blue grosbeak (n=16), indigo bunting (n=6), painted bunting (n=12), Northern cardinal (n=4), ruby-throated hummingbird (*Archilochus colubris*) (n=1), and the Eastern wild turkey (n=2). The remaining 5 nests were from unknown species and no eggs were laid in these nests. A total of 61 nestlings hatched in these nests, of which 33 individuals fledged the nest (n=8 blue grosbeaks, n=4 indigo buntings, n=8 painted buntings, n=13 Eastern wild turkey). Search efforts during the 2006 season used 48.75 man hours or 1.06 man hours per nest.

Nest success increased during the 2006 nesting season. Eggs were laid in 24 of the 46 nests found in 2006. From these 24 nests nest success was found to have increased for blue grosbeak, painted bunting, indigo bunting, wild turkey, and Northern cardinal.

Blue grosbeak nest success increased from 0% to 42.9%. Grosbeaks laid 29 eggs, hatched 12 nestlings, and 8 fledglings left the nest. Two nests fledged offspring, 4 of the remaining 5 nests were predated by snakes, and 1 nest was tipped over during a storm.

Painted bunting nest success increased from 0% in 2005 to 50% in 2006. Painted buntings laid 31 eggs in the nests that we found, of which 15 hatched and 8 fledglings left the nest. Two painted bunting nests fledged offspring, 5 nests were predated by snakes, and 1 nest was turned over during a storm.

Northern cardinal nest success increased from 0% in 2005 to 50% in 2006. The increase of nesting success did not increase productivity of Northern cardinals. One of the 2 nests that received eggs managed to hatch 3 eggs. The nestlings were killed by fire ants (*Solenopsis invicta*) 6 days after hatching. The other nest was predated by a snake.

Indigo bunting nest success increased from 0% in 2005 to 60% in 2006. Indigo buntings laid 17 eggs in 5 nests, of which 8 eggs hatched and 4 fledglings left the nest. Three indigo bunting nests fledged 8 offspring and 2 nests were predated by snakes. A garter snake (*Thamnophis sirtalis*) was seen in the tree where 1 nest was predated.

Brown-headed cowbirds (*Molothrus ater*) laid eggs in 3 of the 5 indigo bunting nests. One of these nests was abandoned soon after the cowbird egg was laid. One indigo bunting kicked out 2 of her eggs and 1 cowbird egg, and still managed to fledge 2 of her own offspring. The other indigo bunting nest had 2 cowbird eggs and 3 bunting eggs. The female kicked out both cowbird eggs and incubated her 3 eggs. Two of these 3 eggs hatched and fledged the nest. The third egg appeared to have been cracked when she kicked out the two cowbird eggs. Indigo buntings managed to fledge their own chicks in 67% of nests that were host to cowbird eggs.

Wild turkey nest success increased from 25% in 2005 to 50% in 2006. Two nests were found in 2006. A total of 22 eggs were laid between the 2 nests. One nest managed to fledge 13 poults. The other nest was predated. The remains of the hen turkey were found about 15 m from the nest. The kill was approximately 1 day old when we found the nest. Characteristics of the kill indicate the predator to have been a bobcat (*Felis rufus*). All eggs at the nest had been broken and consumed. The eggs may have been consumed by the bobcat or by a raccoon.

Nest Site Selection

Nest site locations were analyzed to determine if there was a preference of vegetation treatments for nesting species. Field borders were the most commonly used nesting areas, with 31 nests occurring in this habitat (Table 3.3). Hedgerows held 15 nests during the study. The combined total for nest sites in burn/disk treatment plots was 30 nests.

Nest height in averaged 0.91 m above ground, and ranged from 0 to 2.13 m. Trees and shrubs used for nesting averaged 2.02 m tall and ranged from 0.61 to 7.62 m. The following species were used as nesting trees: Loblolly pine (*Pinus taeda*), Baccharis (*Baccharis halimifolia*), Wax myrtle (*Myrica cerifera*), Sweetgum (*Liquidambar styraciflua*), Black gum (*Nyssa sylvatica*), red maple (*Acer rubrum*), cherrybark oak (*Quercus pagoda*), thunburg lespedeza (*Lespedeza thunbergii*), and Dogfennel (*Eupatorium capillifolium*). The distance of nests from the nearest edge averaged 13.09 m and ranged from 0 to 50 m. The distance of nests from bareground averaged 7.77 m and ranged from 0 to 35 m.

Nest height, nest tree height, distance of nests from the nearest edge, and distance of the nest from bareground were tested for differences between successful and unsuccessful nests of painted buntings, indigo buntings, and blue grosbeaks. We used these 3 species because they had the largest sample sizes and because they have similar nesting behaviors (Ehrlich et al. 1988). The glm procedure indicated that there were no difference in nest height ($\bar{x}$ =1.04 m, p = 0.2642), nest tree height ($\bar{x}$ =2.2 m, p =

0.9770), distance to the nearest edge ($\bar{x}$ =11.5 m, p = 0.9011), or distance to bareground ($\bar{x}$ =6.5 m, p =0.6089) in painted bunting nests.

No differences between successful and unsuccessful indigo bunting nests were detected for nest height ($\bar{x}$ =0.8 m, p = 0.2180), nest tree height ($\bar{x}$ =1.6 m, p = 0.9489), distance to nearest edge ($\bar{x}$ =9.3 m, p =0.4497), or distance to bareground ($\bar{x}$ =7.9 m, p = 0.7706). Likewise, no differences were detected in nest height ($\bar{x}$ =0.9 m, p = 0.9504), nest tree height ($\bar{x}$ =1.6 m, p-val = 0.8359), distance to nearest edge ($\bar{x}$ =8.5 m, p = 0.4616), or distance to bareground ($\bar{x}$ =6.8 m, p = 0.7563) among successful and unsuccessful blue grosbeak nest sites.

Vegetation height measurements were analyzed for painted bunting, indigo bunting, and blue grosbeak nest sites (Table 4.4). Mean vegetation height around painted bunting nest sites ranged from 18 – 60 cm. ANOVA indicated there were differences in mean vegetation height among painted bunting nests ($p \leq 0.0001$). Mean vegetation height around indigo bunting nests ranged from 25 – 58 cm. ANOVA indicated there were differences among nest sites of indigo buntings ($p \leq 0.0001$). Mean vegetation height around blue grosbeak nest sites ranged from 18 – 60 cm, and analysis indicated differences among nest sites existed ($p \leq 0.0001$).

Vegetation height was analyzed for successful and unsuccessful nests. Vegetation height was also analyzed to determine if there were differences between sites selected for nesting and available habitat. ANOVAs indicated there were no differences in mean vegetation height between successful and unsuccessful painted bunting nests (p = 0.1739), indigo bunting nests (p = 0.4473), and blue grosbeaks (p = 0.6842).

Vegetation height was also analyzed to determine if there were differences between sites selected for nesting and available habitat. ANOVAs indicated there were differences in vegetation height at nest sites and random locations for painted buntings ($p \leq 0.0001$), indigo buntings ($p \leq 0.0001$), and blue grosbeaks ($p \leq 0.0001$). Mean vegetation height at random locations was 21 cm. Mean vegetation height at nest sites were as follows: painted bunting = 43 cm, indigo bunting = 43 cm, and blue grosbeak = 36 cm.

Ground cover analysis for painted bunting nest sites indicated there were differences in grass ($\bar{x}$ = 39%, p = 0.0421), forb cover ($\bar{x}$ = 41%, p = 0.0600), woody stems ($\bar{x}$ = 2%, $p \leq 0.0001$), exposed soil ($\bar{x}$ = 8%, p = 0.0013), and debris ($\bar{x}$ = 2%, p = 0.0294) between nest sites. Ground cover analysis for indigo bunting nest sites indicated differences in forb ($\bar{x}$ = 45%, p = 0.0021) and woody stem ($\bar{x}$ = 15%, p = 0.0001) coverage between nests. No differences were detected for grass ($\bar{x}$ = 30%, p = 0.6967), exposed soil ($\bar{x}$ = 4%, p = 0.2484), and debris ($\bar{x}$ = 5%, p = 0.3483) among indigo bunting nest sites.

Ground cover analysis for blue grosbeak nest sites indicated that there were differences in grass ($\bar{x}$ = 31%, p = 0.0001) and debris ($\bar{x}$ = 11%, p = 0.0023) coverage between nests. No differences were detected for forb ($\bar{x}$ = 49%, p = 0.1031), exposed soil ($\bar{x}$ = 5%, p = 0.2156), and woody stem ($\bar{x}$ = 2%, p = 0.2395) coverage among nest sites.

Ground cover was tested between successful and unsuccessful nests. No differences in grass (p = 0.9331), forb (p = 0.4766), woody stem (p = 0.7035), exposed soil (p = 0.4998), and debris (p = 0.5465) were detected between successful and unsuccessful painted bunting nests. No differences in ground cover were detected between successful and unsuccessful indigo bunting nests: grass (p = 0.3746), forb (p = 0.5802), woody stems (p = 0.9902), exposed soil (p = 0.0837), or debris (p = 0.6805).

Nest sites of blue grosbeaks experienced variation in ground cover between successful and unsuccessful nests. Differences were detected in grass (successful = 5%; unsuccessful = 26%; p = 0.0121), forb (p = 0.0358), and debris (successful = 19%; unsuccessful = 11%; p = 0.0171). No differences were detected in woody stem (p = 0.9299) or exposed soil (p = 0.3870) coverage.

Ground cover between nest sites and random sites were analyzed. Differences in grass (selected sites = 13%; random sites = 31%; $p \leq 0.0001$), forbs (selected sites = 54%; random sites = 44%; p = 0.0032), woody stems (selected sites = 23%; random sites = 2%; $p \leq 0.0001$), and exposed soil (selected sites = 2%; random sites = 11%; $p \leq 0.0001$) coverage were detected between painted bunting nest sites and random sites. No difference was detected in debris coverage (p = 0.1225). Analysis of indigo bunting nest sites indicated that there were differences in the amount of woody stem (selected sites = 23%; random sites = 2%; $p \leq 0.0001$) and exposed soil (selected sites = 2%; random sites = 11%; p = 0.0008) coverage between nest sites and random sites. No differences were detected in grass (p = 0.2497), forb (p = 0.7486), and debris (p = 0.9814) coverage. Blue grosbeak nests were different from random sites in coverage of grass (selected sites = 23%; random sites = 31%; p = 0.0100), forbs (selected sites = 53%; random sites = 44%; p = 0.0022), woody stems (selected sites = 9%; random sites = 2%; $p \leq 0.0001$), exposed soil (selected sites = 3%; random sites = 11%; $p \leq 0.0001$), and debris (selected sites = 13%; random sites = 8%; $p = 0.0004$).

Analysis of herbaceous composition around nest sites indicated no differences among nest sites of painted buntings ($p = 0.6223$), indigo buntings ($p = 0.6281$), and blue grosbeaks ($p = 0.9298$). Herbaceous species composition for painted buntings was found to be similar between successful and unsuccessful nests ($p = 0.7349$). Likewise, herbaceous composition was similar between successful and unsuccessful nests for all indigo bunting nests ($p = 0.9793$) and for all blue grosbeak nests ($p = 0.9191$). Comparison of herbaceous composition around nest sites and random sites indicated that there were differences for painted buntings ($p = 0.0447$), but not for indigo buntings ($p = 0.6673$) or blue grosbeaks ($p = 0.7770$).

Analysis of woody stem density around nest sites of painted buntings indicated that there were no differences between nest sites ($\bar{x} = 5.6$ stems/0.02 ha, $p = 0.1554$). No difference was detected between blue grosbeak nests ($\bar{x} = 4.7$ stems/0.02 ha, $p = 0.0679$). Differences were detected in the density of woody stems around nest sites of indigo buntings ($\bar{x} = 5.8$ stems/0.02 ha, $p = 0.0036$). No differences were detected between successful and unsuccessful nests of painted buntings ($p = 0.5633$), indigo buntings ($p = 0.9181$), or blue grosbeaks ($p = 0.3498$).

Woody stem density was compared between random locations and locations that were selected for nesting. Mean woody stem density at random locations was 4.1 stems/0.02ha. Analysis indicated the density of woody stems at nest sites of painted buntings (p = 0.0613), indigo buntings (p = 0.1119), and blue grosbeaks (p = 0.3977) were not different from random sites.

Winter Songbird Field Use

There were differences in the number of songbirds flushed among treatments (p=0.0002) (Table 3.9). Songbirds were selecting certain treatments (Table 3.9), and use was not based on availability of the treatment (Chi-Square = 808.4018; $p \leq 0.0001$). The mean number of birds in a treatment ranged from 0 to 33.5 birds. The mean number of birds was lowest for plots that were burned every summer ($\bar{x}$ =0.667 birds), every other summer ($\bar{x}$ =0.000 birds), every third summer ($\bar{x}$ =0.000 birds). Disking in the winter every other year ($\bar{x}$ =0.000 birds) provided plots that were used little by wintering songbirds. Bird usage was highest in plots that were burned every other spring ($\bar{x}$ =29.00 birds) and every third spring ($\bar{x}$ =33.50 birds). Plots that were burned every other winter ($\bar{x}$ =26.33 birds) and every third winter ($\bar{x}$ =11.00 birds) also received considerable usage. The disk plots that received the most use by songbirds were as follows: disk March or April every other year ($\bar{x}$ =7.000 birds) and every third year ($\bar{x}$ =7.000 birds) and plots disked annually in May or Junes ($\bar{x}$ =9.000).

Discussion

Nest Success

Nest searches conducted during the study found 76 nests within the study area. Nest searching was more productive in 2006 (n=46 nests). The increase in nests found may be attributable to experience gained during the 2005 season. Another possible explanation would be the later green-up experienced in 2006. No nests were found in Thunburg lespedeza hedgerows in 2005, but in 2006 we found 18 nests in these hedgerows. Nests were difficult to find in hedgerows once the shrubs were fully leaved out. Hedgerows leaved out later in 2006 than 2005.

During the 2 year study 39 of the 76 nests received at least one egg. Unidentified nests accounted for 15 nests in 2005 and only 5 nests in 2006. Nests were difficult to identify that didn't have eggs in 2005. Experience gained in 2005 made nest identification easier in 2006. Six nests were found without eggs in 2006 and later received eggs. These nests were identified before eggs were laid, and monitoring proved the identification to be correct once eggs had been laid. Nests that didn't have eggs were identified based on nest shape, nest size, cup width, and building materials. Blue grosbeak and painted bunting nests were the most commonly found in the study area. These nests were located in very similar habitat and had a similar appearance. Blue grosbeak nests were slightly larger in overall size and cup width. Blue grosbeak nests were generally fancier in outer appearance than painted bunting nests. Grosbeaks typically decorated the outside of their nests with cane, moss, plastic, or snakeskin. Both species used grass and forb remains to construct their nests. They both lined the inside of their nests with Spanish moss (*Tillandsia usneoides*), grass, or fine strips of tree bark.

Nest Predation

Nest predation was primarily attributed to snakes and raccoons during the study. Raccoons primarily predated turkey nest. No evidence suggested that raccoons predated songbird nests that were built off the ground. Snakes were blamed for the predation of 17 songbird nests that were built in saplings and shrubs. Nest searching frequently revealed snakes in shrubs within the study area. On one occasion during the 2006 nesting season 5 snakes were seen in shrubs in one plot. Snakes were commonly encountered in shrubs and saplings following rains. Five species of snakes were observed in above ground vegetation during the study. Snakes encountered included: garter snake (*Thamnophis sirtalis*), yellow rat snake or chicken snake (*Elaphe obsolete quadrivittata*), black racer (*Coluber constrictor*), and the rough green snake (*Opheodrys aestivus*).

Raccoons were blamed for the failure of 4 nests. Raccoons primarily predated wild turkey nests. We found no evidence to suggest that raccoons predated above ground nests of early-successional songbirds. Land managers focusing on ground nesting birds in the lower Coastal Plain may need to initiate raccoon population management practices into their management programs.

A wild turkey hen was predated while nesting during the 2006 nesting season. The hen had been dragged a short distance from the nest. The viscera and part of the breast had been consumed. The partially eaten carcass was cached in thick vegetation. Vegetative debris had been pulled over the carcass and partially covered it. These characteristics indicated that a bobcat was responsible for the kill.

Brood-Parasitism

Brown-headed cowbirds (*Molothrus ater*) laid eggs in 3 of the 5 indigo bunting nests. Indigo buntings managed to fledge their own offspring in 67% of nests that were host to cowbird eggs. Indigo buntings kicked cowbird eggs out of there nests on 2 occasions. One indigo bunting nests was abandoned soon after a cowbird egg was laid. These results indicate that indigo buntings may have adapted to overcome the brood parasitism of brown-headed cowbirds.

Variability in Nest Success and Productivity

The results of the nesting success portion of this study indicate that there may be variability in the nesting success and productivity of early-successional bird species from year to year. Success rates appeared to fluctuate from year to year, but a combined look at rates from both years indicate that success was similar to other studies. Research conducted by Aimee Weldon (2006) in Aiken, South Carolina during the 2002-2003 nesting seasons found indigo bunting nest success to be 46%. Indigo bunting nest success for this study was 43%. Our results indicate that success of early-successional nesters may need to be evaluated over time periods longer than 1-2 years. Further research is needed to gain a better understanding of the productivity of these species. Long term (10 or more years) may provide more accurate information on nest success and productivity of early-successional bird species.

Nest Site Selection

Nest sites were most commonly found in field borders (n=31) and hedgerows (n=15). A combined total for all vegetation treatments received 30 nests. This indicates nest sites were targeted near edges and inner portions of the fields were less preferred by nesting species. These results emphasize the importance of field managers to include the development and maintenance of hedgerows and field borders into their management plans or practices.

The height of vegetation around nest sites varied within species for painted buntings, indigo buntings, and blue grosbeaks. Nest sites for all three species occurred in areas that had a mean vegetation height approximately twice as tall as heights found at random sites. This suggests that the species sought out areas of taller vegetation for use as nesting areas. The height of vegetation surrounding nest sites didn't affect the successes of the above mentioned species.

Results of ground cover classification around nest sites indicated that songbird species selected different nesting habitat. Results from ground cover analysis around successful verses unsuccessful nest indicated that ground cover had little affect on the nest sites of painted buntings, indigo buntings, and blue grosbeaks. Habitat chosen for nesting had differences in ground coverage compared to available habitat. The most notable difference in nest sites and available habitat was the higher percentage of woody stem ground coverage found at nest sites. Land managers should not focus on maintaining high woody stem coverage in old fields. Emphasis should remain on controlling woody stems, as competition from woody stems may be detrimental to beneficial grass and forb species. Nesting birds will be able to locate suitable nesting cover in fields managed for early-successional habitat.

Herbaceous species composition was found to be similar between species, years, and successful and unsuccessful nests. Herbaceous composition was also similar between nest sites of indigo buntings and blue grosbeak and available habitat. Nest sites of painted buntings were different from available habitat in the number and coverage of grass species present. Painted bunting nest sites typically had about half the amount of grass coverage as what was found at random sites.

The most commonly found species around nest sites was dewberry (*Rubus* spp.). Other species that were common around nest sites include: Goldenrod (*Solidago* spp.), Broomsedge (*Andropogon virginicus*), Panic grass (*Panicum* and *Dichanthelium* spp.), Rush (*Juncus* spp.), and Dogfennel (*Eupatorium capillifolium*). These species were the most common among all nesting species found during this study. These results indicated that niche separation of songbirds nesting in the fields may have been linked more with ground cover than species composition

Woody stem density was found to be similar around the nest sites of all painted buntings and all blue grosbeaks. Differences in the density of woody stems were observed among indigo bunting nest sites. No differences were detected between successful and unsuccessful nests of any of the three species. Woody stem density around the nest sites was not different from densities found at random locations. These results indicate that niche separation among species was not related to woody stem density. Results also indicate that nest sites were generally placed in areas with scattered shrubs and saplings. The stem densities selected by nesting songbirds was common among treatments applied in the vegetation study. The only disturbance treatment that provided higher mean stem densities than the bird preference was burning every third summer. No nests were found in triennial summer burn treatment plots during the study.

Winter Songbird Field Use

Wintering songbird use was found to be different among treatments. There was no apparent relationship between size of treatments and the number of birds using the treatment. This indicates that birds selected certain treatments without regard to the availability of the treatment. Treatments that received the least use by wintering birds were summer burns. Spring and winter burn plots received the greatest use by wintering songbirds.

Comparison of vegetation variables between treatments that received high usage by wintering songbirds and treatments that received low usage by wintering songbirds indicated limited variation. Use of treatment plots may have been more strongly influenced by variables that were not measured in this study. Variation of vegetation variables within treatments may have limited the data sets usefulness at determining wintering songbird usage. Vegetation variables that were not measured in this study may provide a clearer insight as to why wintering songbirds were more plentiful in plots that were burned in the spring or winter. Wintering songbird use of study plots may have been affected by the location of plots. Study plots located in one particular field received more usage than plots in other fields with the same treatments. The mentioned field was comprised of 9 plots all of which received burn treatments. This field was isolated from all other fields in the study, and was located within a mature mixed pine/hardwood stand. High bird usage of this entire field may indicate that location has some influence on bird usage.

Management Implications

Land managers interested in creating early-successional habitat for songbirds in the lower Coastal Plain of South Carolina should benefit the use of prescribed burns applied during the spring. Spring burns conducted at 2 year frequencies provided quality nesting and wintering habitat for a variety of early-successional songbirds. Conducting spring burns less frequently is discouraged as long growing seasons and high annual rainfall allow woody species to dominate early-successional habitat. Spring burns may need to be supplemented with spot herbicide applications for woody stem control to insure that the habitat remains dominated by grasses and forbs. Land managers are also encouraged to develop and maintain field borders and hedgerows within their fields. These habitats received heavy use and were particularly important to nesting songbirds.

Summary

Nest Success

Early-successional songbird species at Nemours Plantation experienced immense variation in nesting success and productivity between years. Overall, productivity was low for all species during both years of this study. Primary causes of nest failure were destruction of nests by storms and depredation of nests by snakes. No clear solution to the failure of early-successional nesters was found during this study. It may be impossible for land management practices to overcome the destructive forces of weather and predation in this scenario.

More studies are needed to determine if nest success and productivity would be better measured over longer time periods. Future studies are also needed to determine if productivity at the low level experienced in this study are capable of sustaining early-successional bird species.

Nest Site Selection

Nest site selection was similar for many vegetation variables among painted bunting, indigo bunting, and blue grosbeak nests. Differences in sites selected for nesting and sites available were observed. Nest sites were primarily selected in areas that had taller vegetation and a higher percentage of woody stem ground cover than the available habitat. Nesting success was not affected by sites chosen.

Results of this study demonstrated the importance of managing for early-successional habitat. Painted buntings, indigo buntings, and blue grosbeaks made extensive use of the fields being maintained in early-successional habitat. Field borders and hedgerows were also identified as desired nesting habitat for early-successional songbird species. Managing lands to promote a mosaic of vegetation characteristics seemed to provide songbirds with the habitat characteristics needed to suite their individual niche.

Winter Songbird Field Use

Wintering birds were found to use treatments differently. Bird numbers were highest in plots that were treated with spring and winter burns. Bird numbers were lowest in plots that were treated with summer burns. The vegetation variables measured in the vegetation study were unable to predict which treatments would receive the highest use by wintering birds. Total area comprised by a treatment had no affect on bird presence. Bird usage was speculated to have been linked to field location.

Table 3.1: Nest success and productivity for 2005. Nesting bird species, number of nests found, number of eggs recorded, number hatchlings recorded, number of fledglings recorded, and percentage of successful nests during the 2005 nesting season.

Species	Nests	Eggs	Chicks	Fledglings	Success
Blue Grosbeak	4	12	0	0	0
Indigo Bunting	1	1	0	0	0
Painted Bunting	4	11	0	0	0
Northern Cardinal	1	3	0	0	0
Wild Turkey	4	43	7	7	25%
Brown Thrasher	1	4	4	4	100%
Unknown	15	0	0	0	

% Success includes only nests in which at least 1 egg was laid

Table 3.2: Nest success and productivity for 2006. Nesting bird species, number of nests found, number of eggs recorded, number hatchlings recorded, number of fledglings recorded, and percentage of successful nests during the 2006 nesting season.

Species	Nests	Eggs	Chicks	Fledglings	Success
Blue Grosbeak	16	29	12	8	37.50%
Indigo Bunting	6	17	8	4	50%
Painted Bunting	12	31	15	8	50%
Northern Cardinal	4	6	3	0	50%
Wild Turkey	2	13	13	13	100%
Hummingbird	1	0	0	0	
Unknown	5	0	0	0	

% Success includes only nests in which at least 1 egg was laid

Table 3.3: Songbird selection of nesting habitat. Field treatment, number of nests found, and percent of total study area comprised by the treatment.

Treatment	# Nests	% of Study Area
Field Border	31	14.30%
Hedgerow	15	0.44%
Burn Spring 1	0	8.60%
Burn Spring 2	3	5.70%
Burn Spring 3	0	2.90%
Burn Summer 1	3	5.50%
Burn Summer 2	0	6.00%
Burn Summer 3	0	3.50%
Burn Winter 1	2	6.40%
Burn Winter 2	2	6.70%
Burn Winter 3	1	2.60%
Disk Spring 1	0	2.40%
Disk Spring 2	1	2.70%
Disk Spring 3	0	3.30%
Disk Summer 1	1	8.00%
Disk Summer 2	1	7.40%
Disk Summer 3	3	6.10%
Disk Winter 1	1	5.10%
Disk Winter 2	3	5.50%
Disk Winter 3	1	3.60%

Table 3.4: Mean vegetation height around nest sites. Nesting bird species, mean vegetation height at nest sites, and p-value from ANOVA within species.

Species	Mean Vegetation Height (cm)	P-value
Blue Grosbeak	34.61	<0.0001
Indigo Bunting	44.89	<0.0001
Painted Bunting	42.42	<0.0001
Random Locations	21	

Table 3.5: Ground cover percentages around nest sites. Nesting bird species, mean grass cover percentage, mean forb cover percentage, mean woody cover percentage, mean soil cover percentage, and mean debris cover percentage.

Species	% Grass	% Forb	% Wood	% Soil	% Debris
Blue Grosbeak	32	49	2	5	11
Indigo Bunting	30	45	15	4	5
Painted Bunting	39	41	2	8	3
Random Locations	31	44	2	11	8

Table 3.6: List of plant species found around nest sites. Grass species, forb species, vine species, and tree or shrub species found around nest sites.

Grass	Forb	Vine	Tree/Shrub
Andropogon virginicus	*Agalinis fasciculata*	*Ampelopsis arborea*	*Acer rubrum*
Carex cephalophora	*Ambrosia artemisiifolia*	*Rubus* spp.	*Baccharis halimifolia*
Cyperus echinatus	*Asplenium platyneuron*		*Diospyros virginiana*
Dichanthelium spp.	*Conyza canadensis*		*Liquidambar stryaciflua*
Digitaria ciliaris	*Crotalaria spectabilis*		*Morella cerifera*
Eragrostis spectabilis	*Erigeron annus*		*Pinus taeda*
Juncus spp.	*Eupatorium capillifolium*		*Quercus falcate*
Panicum spp.	*Gamochaeta purpea*		*Quercus pagoda*
Paspalum urvillei	*Hypericum gentianoides*		*Sapium sebiferum*
Setaria glauca	*Lespedeza virginica*		
	Lespedeza thunburgii		
	Ludwigia alternifolia		
	Melochia corchorifolia		
	Mollugo verticillata		
	Oxalis stricta		
	Polygonum hydropiper		
	Rhexia spp.		
	Senna obtusifolia		
	Sesbania herbacea		
	Verbena brasiliensis		

Table 3.7: Woody stem density around nest sites. Nesting bird species, mean number of woody stems at nest sites, and p-value from ANOVA within species.

Species	# Stems	P-value
Blue Grosbeak	4.71	0.0679
Indigo Bunting	5.46	0.0036
Painted Bunting	5.59	0.1554
Random Locations	4.15	

Table 3.8: Wintering songbird use of early-successional habitat. Designated treatment, mean number of songbirds flushed, standard deviation of the mean number of songbirds flushed during winter drive counts of 2006.

Treatment	Mean Birds	Standard Deviation
Burn as Needed	3.862	4.365
Burn Spring 1	7.778	9.871
Burn Spring 2	29.000	40.254
Burn Spring 3	33.500	40.305
Burn Summer 1	0.667	0.577
Burn Summer 2	0.000	0.000
Burn Summer 3	0.000	0.000
Burn Winter 1	3.571	3.994
Burn Winter 2	26.333	21.385
Burn Winter 3	11.000	12.728
Disk Spring 1	1.667	2.887
Disk Spring 2	7.000	6.245
Disk Spring 3	7.000	12.124
Disk Summer 1	5.333	6.964
Disk Summer 2	3.000	2.693
Disk Summer 3	3.444	4.590
Disk Winter 1	2.167	5.307
Disk Winter 2	0.667	1.211
Disk Winter 3	1.333	1.506

Table 3.9: Songbird use in relation to habitat availability. Designated treatment, number of birds flushed, percentage of total number of birds flushed, size of treatment in hectares, percentage of total area, and expected number of birds flushed based on size of treatment.

Treatment	# Birds	% of Total Birds	Size of Treatment (ha)	% of Total Area	Expected Number of Birds
Native Warm-Season Grass Plots	48	7.30%	2.87	7.90%	52
Burn Spring 1	61	9.30%	3.1	8.60%	56
Burn Spring 2	183	27.80%	2.05	5.70%	37
Burn Spring 3	62	10.00%	1.04	2.90%	19
Burn Summer 1	1	0.15%	1.99	5.50%	36
Burn Summer 2	1	0.15%	2.18	6.00%	39
Burn Summer 3	0	0.00%	1.26	3.50%	23
Burn Winter 1	10	1.50%	2.3	6.40%	42
Burn Winter 2	94	14.00%	2.42	6.70%	44
Burn Winter 3	22	3.00%	0.95	2.60%	17
Disk Spring 1	5	0.80%	0.86	2.40%	15
Disk Spring 2	21	3.20%	0.97	2.70%	17
Disk Spring 3	21	3.20%	1.21	3.30%	21
Disk Summer 1	44	6.50%	2.89	8.00%	51
Disk Summer 2	27	4.10%	2.69	7.40%	47
Disk Summer 3	37	5.90%	2.22	6.10%	39
Disk Winter 1	13	2.00%	1.85	5.10%	33
Disk Winter 2	1	0.15%	2	5.50%	36
Disk Winter 3	8	1.20%	1.31	3.60%	23

CHAPTER 4

NORTHERN BOBWHITE HABITAT USE IN RESPONSE TO FIELD MANAGEMENT PRACTICES

Abstract

We evaluated bobwhite habitat use in the lower Coastal Plain of South Carolina. The study was conducted on 400ha matrix of fields and woodlands. Field areas were under management for early-successional habitat, as well as, native warm-season grasses, field borders, and hedgerows. Woodlands in the study area were comprised of mature mixed pine/hardwood stands and hardwood bottoms. Bobwhite locations predominately occurred in mature mixed pine/hardwood stands. Field habitat components receiving the most use were ditch-lines, hedgerows, food plots, field borders, and hardwood islands. Bobwhite locations rarely occurred in interior portions of the fields that were under management for early-successional habitat. Comparison of the size of available habitats and the number of recorded bobwhite locations indicated that habitat use was not based on size/availability of habitat. Three bobwhite mortalities were recorded during the study. Bobwhite predation was believed to have been caused by birds of prey (n=2) and bobcats (n=1).

Introduction

Bobwhite populations have been declining at a drastic pace for the past half century (Capel et al. 1995). The decline of bobwhite populations has been attributed to changes in land use and loss of habitat (Burger 2004, Brennan 1991, Langer 1989, MacGowen 2001). Farming practices of the past provided woody hedgerows, field borders, weedy fields, woody fence lines, abundant edge habitat, and plenty of insects (Chumchal 1995, Mahan and Carmicheal 1995). The early-successional habitat provided by farms of the past was very beneficial to the biological needs of bobwhites (Mahan and Carmicheal 1995). Early-successional habitat requires regular disturbance to remain beneficial to bobwhites. In the absence of disturbance old-field habitat quickly becomes dominated by shrubs and trees and beneficial grasses and forbs are out competed (MacGowen 2001). The objective of this study is to evaluate field management practices for early-successional habitat, and to determine what the effects of these management practices have on bobwhite habitat use.

Study Area

This study was conducted at Nemours Plantation, which is operated by Nemours Wildlife Foundation (NWF). NWF was established in 1995 by Eugene DuPont III and family. NWF is a private 501(c)(3) operating foundation and is administered by a board of directors. Primary focuses of the foundation include: research, education, and stewardship of natural resources.

Nemours Plantation is a 4,000 ha track of land located in Beaufort County, South Carolina. The plantation lies within the Ashepoo-Combahee- Edisto (ACE) River Basin, which is located in the lower Coastal Plain, and has been designated as one of the last great places on earth by The Nature Conservancy. The plantation contains a diverse assemblage of habitats including remnant rice fields, fresh and brackish marshes, pine savannahs, upland pine and hardwood forests, bottomland hardwood forests, cypress/tupelo swamps, maritime forests, and abandoned agriculture fields.

This study focuses on the management of abandoned agriculture fields as grass-shrub habitats. The study area was approximately 400 ha, and consisted of 14 fields and their associated woodlands. Field size ranged from approximately 0.4 ha to 22.7 ha. Average field size was 7.5 ha. Prior to the abandonment of agriculture practices, the fields had been used for row cropping (corn/soybean) and pasture for dairy cattle.

Early-successional habitat management practices were implemented within the 14 fields in 2000. Management practices implemented include burn plots, disc plots, native warm-season grass plots, Thunberg lespedeza hedgerows, and field borders. Field management practices had been in place for 4 years prior to the start of this project.

Methods

Bobwhites were captured with standard funnel traps (Schemnitz 1996). Trap sites were baited with sorghum for 3-5 days prior to traps being set. Traps were set at sites that had been visited by birds. Traps were checked twice daily, once at mid-morning and again after dark. Captured bobwhites were transported to a central location where they were sexed, weighed, aged, banded, and fitted with a radio-transmitter. Birds were held overnight and released the next morning. Sex was determined by plumage characteristics. Weight was obtained by placing the bird in a mesh-bag and weighing to the nearest gram using a hanging scale. Age was determined using the loss or replacement of wing primary feathers (Petrides and Nestler 1952). Leg bands containing an individual identification number were attached to one leg of the bobwhite. Radio-transmitters were placed around the bird's neck using a necklace configuration. Total weight for the transmitter outfit was ≤ 6 grams. Transmitter signals were in the 150.000-151.999 MHz range. The transmitters were tested prior to being affixed to the birds. Transmitters were tied around the neck of the bird and the antennae were laid over the back for the birds to prune into their feathers. Under optimal conditions the transmitters had a range of approximately 0.8 km.

Locations were recorded on the collared birds during this study 2-3 times daily. Telemetry was conducted early to mid-morning, afternoon, and at dusk. Collared birds were monitored using a modified homing radio-telemetry technique (Mech 1983, Samuel and Fuller 1996). The technique was modified in an effort not to flush birds, as that may have taken away from the accuracy of the habitat use data. We used the technique to accurately place the birds in a habitat type. We used a GPS unit to record our location, and took a compass bearing in the direction of the bird. Distance from our location to the location of the bird was estimated. GPS locations were converted to the birds' x and y coordinates using the compass bearings and distance estimate.

Analysis

Bobwhite habitat use data collected during this study was analyzed using Statistical Analysis System (SAS) (SAS Institute, Inc., © 2003). A goodness of fit test was conducted to compare habitat use with habitat availability in order to determine if habitats were used based on availability. We hypothesized that the use of habitat by bobwhites was based on the availability of habitat. Hypothesis were tested at the α=0.10 level.

Results

Trapping

Bobwhite trapping efforts were unsuccessful in 2005. Trapping began in January and lasted until mid-March. The number of active traps (traps set and capable of catching bobwhites) ranged from 5 to 35 traps, and averaged 24 traps. Traps were set for a total of 54 days, or approximately 1,296 trap days (average # traps x # days set). During the 2005 trapping season a total of 6 non-target bird species totaling 105 individuals and 1 mammal were captured. Bird species captured included Northern cardinal (*Cardinalis cardinalis*) (n=40), brown thrasher (*Toxostoma rufum*) (n=26), dark-eyed junco (*Junco hyemalis*) (n=12), rufous-sided towhee (*Pipilo erythrophthalmus*) (n=11), hermit thrush (*Catharus guttatus*) (n=9), and gray catbird (*Dumetella carolinensis*) (n=7). The only mammal species captured was the opossum (*Didelphis virginiana*) (n=1). All non-target species were released at the trap site.

During the 2006 trapping season the number of active trap sites ranged from 10 to 40, and averaged 21. Traps were set for a total of 35 days, or approximately 735 trap days (average # traps x # days set). During the trapping session 58 non-target species were captured. Non-target species included the Northern cardinal (n=25), brown thrasher (n=11), rufous-sided towhee (n=6), dark-eyed junco (n=6), hermit thrush (n=6), and gray catbird (n=4). All non-target species were released at trap sites. Trapping efforts in 2006 produced 11 bobwhites and 4 recaptures. Bobwhites captured (n=11) consisted of 6 males and 5 females, of which there were 7 juveniles and 4 adults.

<u>Habitat Use</u>

A total of 951 locations on 11 individuals were recorded during the study (Table 4.1). Treatment plots within the fields accounted for 50 locations. Analysis of locations indicated no relationship between the amount of a habitat and the number of locations recorded there (meaning they had a preference for certain habitat types) (Chi-Square = 2021.7174, $p \leq 0.0001$).

Treatment plots disked in the summer every other year (7.4% of total study area) received the most use (n=27; 2.8% of total locations) of all treatment plots by Northern bobwhites. Wooded ditch lines (9.3% of total locations; 0.89% of the total study area), lespedeza hedgerows (4.5% of total locations; 0.44% of the total study area), and food plots (4.2% of total locations; 1.95% of the total study area) made up only a small amount of the total study area, but were frequently used by bobwhites . Other field components that were used by bobwhites included hardwood islands (2.8% of total locations; 0.8% of the total study area), gum ponds (2.3% of total locations; 0.33% of the total study area), and native warm-season grass plots (0.42% of total locations, 1.28% of the study area). The majority of bobwhite locations (n=591; 61.95% of total locations) recorded during this study were in mature pine stands (41.82% of the study area).

Bobwhite telemetry data was limited to the small sample size (n=11) and heavy losses (n=10) during the monitoring period. An adult female was recaptured within a day of being released, at which time she lost her transmitter in the process of escaping. Overall, 3 birds lost their radio-collars. Three birds disappeared from the study area in April. One of these 3 returned to the site after an absence from the site of 3 weeks. The batteries in 2 of the transmitters failed during the study. Three mortalities were recorded during the study. Bird #0148 (male) was killed by a bobcat in the middle of a food plot on June 23, 2006. Two mortalities were caused by avian predation. The first kill occurred during the last week of April. Bobwhite #0145 (male) was carried back to the nest of a red-shouldered hawk (*Buteo lineatus*). The transmitter was recovered on May 1, 2006, after a thunderstorm knocked the nest out of a large loblolly pine tree (*Pinus taeda*). Two dead red-shouldered hawk nestlings were found on the ground near the transmitter and nest remains.

Bobwhite #0141 (female) was killed by an avian predator on July 17, 2006. The remains of this bobwhite were found approximately 3 m off the ground in a live oak (*Quercus virginiana*). Only 1 bobwhite survived through the study.

Discussion

Results of the bobwhite habitat use portion of this study indicated field management practices may be very important to bobwhite populations. Bobwhite use of habitats was not related to the proportion of the study area that the habitats comprised. There appeared to be selection for certain habitat(s).

These results suggest ditch lines within agricultural fields should be allowed to develop into grass ways , and not mowed regularly. The ditch lines provided protective cover, feeding areas, and travel routes. Males were also observed calling from the trees growing along ditch lines. Field borders were used for feeding, traveling, and roosting. Hedgerows were used much like the ditch lines. The Thunberg lespedeza hedgerows provided bobwhites with overhead cover, food supplies, and seemed to function as travel corridors within study fields.

Bobwhites were frequently located in mature pine stands. These stands bordered fields and covered 42% of the study area. The mature pine stands had been through several thinnings and had a low basal area (< 60ft² of basal area). The stands were maintained with regular burning. The ground layer of the stands was dominated by grass and forb species and intermixed with shrubs and saplings. These stands likely provided cover and food. The quality of the habitat that was provided by these pines may be the reason that bobwhites spent so much time in them, and not in the fields. Extensive use of pine stands indicates that interspersed woodlands with fields may be important to the bobwhite.

Summary

Field management practices designed for the benefit of bobwhites are critical. Bobwhite usage of the interior portions of fields may be limited due the edge preference of bobwhites (Chumchal 1995). Providing edge within fields allowed bobwhites to travel across and between fields. The use of edge by bobwhites was apparent in this study.

Ditch lines, field borders, and hedgerows were used by collared birds on this study. Managers of fields should incorporate these field components into their management practices, focusing on providing suitable cover, ample travel lanes, and sufficient food supplies. Prescribed burns offer a simple and cost effective management tool for the maintenance of early-successional habitat, field borders, hedgerows, and ditch lines. In the lower Coastal Plain, prescribed burns should be used to maintain field components at least every three years. Burning less frequently than every 3 years may allow woody species to shade out grass and forb species that are utilized by bobwhites.

Table 4.1: Bobwhite use of early-successional habitat. Habitat type, number of bobwhite occurrences, percent of total bobwhite occurrences, percent of study area that habitat type comprised, and the expected number of bobwhite occurrences based on size of habitat.

Habitat	Occurrences	% of Total Occurrences	% of Study Area	Expected # of Occurrences
Mature Pines	591	61.95%	41.82%	398
Wooded Ditch Lines	89	9.33%	0.89%	8
Lespedeza Patches	43	4.51%	0.44%	4
Food Plots	40	4.19%	1.95%	19
Field Borders	54	5.60%	14.30%	136
Hardwood Bottoms	28	2.94%	32.72%	311
Hardwood Islands	27	2.83%	0.80%	8
Disk Summer 2	27	2.83%	7.40%	70
Gum Pond	22	2.31%	0.33%	3
Disk Winter 3	10	1.05%	3.60%	34
Native Warm Season Grass Plots	4	0.42%	1.28%	12
Burn Summer 2	3	0.31%	6.00%	7
Hickory Shed Field	2	0.21%	1.80%	17
Burn Spring 2	2	0.21%	5.70%	5
Burn Winter 1	2	0.21%	6.40%	5
Burn Winter 2	2	0.21%	6.70%	6
Live Oak Tree	1	0.10%	0.00%	0
Disk Summer 3	1	0.10%	6.10%	58

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